MEMOIRS

OF THE

AMERICAN ACADEMY

OF

ARTS

AND

SCIENCES:

TO THE END OF THE YEAR M,DCC,LXXXIII.

VOLUME I.

BOSTON:

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M,DCC,LXXXV.

PREFACE.

MANKIND have ever found a state of society subservient to their comfort and happiness. Subjected to many wants, they have been able, by an union one with another, to obtain that supply, which would have been impracticable if each individual had stood alone; and invariable experience has taught, that the social bond is the greatest security against the numberless dangers and difficulties, to which they are exposed. Hence the many political or civil institutions, that have been formed in the world, which have been greater or less blessings to the persons, who have belonged to them, in proportion as those institutions have been framed with more or less wisdom, and the members of them have been more or less virtuous and prudent.

Societies for promoting useful knowledge may be highly advantageous to the communities, in which they are instituted. Men united together, and frequently meeting for the purpose of advancing the sciences, the arts, agriculture, manufactures and commerce, may oftentimes suggest such hints to one another, as may be improved to important ends: and such societies, by being the repositories of the observations and discoveries of the learned and ingenious, may, from time to time, furnish the world with useful publications, which might otherwise be lost: for men of ingenuity, and modesty, may not chuse to risk their reputation, by sending abroad, unpatronized, what a learned society might judge richly worthy the public eye; or, perhaps, their circumstances being straitened, they may not be able to defray the expence of publication. Societies instituted for promoting knowledge, may also be of eminent service, by exciting a spirit of emulation, and enkindling those sparks of genius, which otherwise might forever have been concealed; and if, when possessed of funds sufficient for the purpose, they reward the exertions of the industrious and enterprising, with pecuniary premiums or honorary medals, many important experiments and useful discoveries will be made, from which, the public may reap the highest advantages.

Eminent instances of the beneficial effects of such institutions we have, in the Royal Academy of Sciences at *Paris*, the Royal Society, and the Society instituted for the encouragement of Arts,

Manufactures

Manufactures and Commerce, in *London*, and many others of a similar kind, in *Europe*. Hereby a spirit of discovery and improvement has been excited among the ingenious, in almost every nation, in that quarter of the world; and knowledge of various kinds, and greatly useful to mankind, has taken place of the dry and uninteresting speculations of schoolmen; and bold and erroneous hypothesis has been obliged to give way to demonstrative experiment. In short, since the establishment of these societies, solid learning and philosophy have more increased, than they had done for many centuries before.

But the spirit of promoting knowledge, by instituting literary societies, has not been confined to *Europe*: It has found its way to *America*. Some years ago, a number of gentlemen in *Philadelphia*, voluntarily formed themselves into a society, by the title of, The *American* Philosophical Society. They have published one volume of transactions, which has done them honor.

In this Commonwealth, a society for promoting useful knowledge was, for many years, in contemplation; but the design was never vigorously engaged in and pursued, 'till the end of the year 1779, when many gentlemen, persuaded of the utility of such an institution, determined, without delay, to use their endeavors, to have one formed upon a liberal and extensive plan, and at the same time, to have it established upon a firm basis, by obtaining the sanction of the Legislature. And to the honor of our political Fathers be it spoken, that although the country was engaged in a distressing war, a war the most important to the liberties of mankind, that was ever undertaken by any people, and which required the utmost attention of those, who were entrusted with our public concerns, they immediately adverted to the usefulness of the design, entered into its spirit, and incorporated a society, with ample privileges, by the name of, *The American Academy of Arts and Sciences*. The purpose of this institution is to promote most branches of knowledge advantageous to a community, as will appear, by the following charter of incorporation, which was granted May 4, 1780.

"An ACT to incorporate and establish a Society for the cultivation and promotion of Arts and Sciences."

" *AS the Arts and Sciences are the foundation and support of agriculture, manufactures, and commerce; as they are necessary to the wealth, peace, independence and happiness of a people; as they essentially promote the honor and dignity of the government which patronises them; and*

as

" *as they are most effectually cultivated, and diffused through a State,*
" *by the forming and incorporating of men of genius and learning into*
" *public societies: For these beneficial purposes,*

" *Be it therefore enacted by the Council and House of Representatives in* " *General Court assembled, and by the authority of the same,* That the " Hon. *Samuel Adams*, Esq; Hon. *John Adams*, Esq; *John Bacon*, " Esq; Hon. *James Bowdoin*, Esq; Rev. *Charles Chauncy*, D. D. Rev. " *John Clark*, *David Cobb*, Esq; Rev. *Samuel Cooper*, D. D. Hon. " *Thomas Cushing*, Esq; Hon. *Nathan Cushing*, Esq; Hon. *William Cushing*, Esq; *Tristram Dalton*, Esq; Hon. *Francis Dana*, Esq; Rev. " *Samuel Deane*, Rev. *Perez Fobes*, Rev. *Caleb Gannett*, Hon. *Henry* " *Gardner*, Esq; Mr. *Benjamin Guild*, Hon. *John Hancock*, Esq; Hon. " *Joseph Hawley*, Esq; *Edward Augustus Holyoke*, Esq; Dr. *Ebenezer* " *Hunt*, *Jonathan Jackson*, Esq; Dr. *Charles Jarvis*, Rev. *Samuel* " *Langdon*, D. D. Hon. *Levi Lincoln*, Esq; Rev. *Daniel Little*, Rev. " *Elijah Lothrop*, *John Lowell*, Esq; Rev. *Samuel Mather*, D.D. *Samuel* " *Moody*, Esq; Hon. *Andrew Oliver*, Esq; Dr. *Joseph Orne*, Dr. " *Theodore Parsons*, Hon. *George Partridge*, Esq; Hon. *Robert Treat* " *Paine*, Esq; Rev. *Phillips Payson*, *Samuel Phillips*, jun. Esq; Hon. " *John Pickering*, Esq; Hon. *Oliver Prescot*, Esq; Rev. *Zedekiah* " *Sanger*, Hon. *Nathaniel Peaslee Serjeant*, Esq; *Micajah Sawyer*, Esq; " *Theodore Sedgwick*, Esq; Hon. *William Sever*, Esq; *Stephen Sewall*, " Esq; Hon. *David Sewall*, Esq; *John Sprague*, Esq; *Ebenezer Storer*, " Esq; *Caleb Strong*, Esq; Hon. *James Sullivan*, Esq; Dr. *John Bernard* " *Sweat*, Mr. *Nathaniel Tracy*, *Cotton Tufts*, Esq; Hon. *James Warren*, " Esq; Rev. *Samuel West*, Rev. *Edward Wigglesworth*, Rev. *Joseph* " *Willard*, Rev. *Samuel Williams*, Rev. *Abraham Williams*, Rev. *Nehemiah* " *Williams*, and Mr. *James Winthrop*, be, and they hereby are formed " into, constituted and made a Body Politic and Corporate, by the " name of THE AMERICAN ACADEMY OF ARTS AND SCIENCES; " and that they and their successors, and such other persons as " shall be elected in the manner hereafter mentioned, shall be, and " continue a Body Politic and Corporate, by the same name forever.

" *And be it further enacted by the authority aforesaid,* That " the Fellows of the said Academy may from time to time " elect a President, one or more Vice Presidents, one or more " Secretaries, and such other Officers of the said Academy, as they " shall judge necessary or convenient; and they shall have full " power and authority from time to time to determine and esta- " blish the names, number and duties, of their several officers, and " the tenure or estate they shall respectively have in their offices; " and also to authorize and impower their President, or some

" other

" other Fellow of the Academy, at their pleaſure, to adminiſter
" ſuch oaths to ſuch officers as they ſhall appoint and determine,
" for the well ordering and good government of the ſaid Academy :
" provided the ſame be not repugnant to the laws of this State.

" *And be further enacted by the authority aforeſaid*, That the Fellows
" of the ſaid Academy ſhall have one common ſeal, which they
" may make uſe of in whatſoever cauſe or buſineſs ſhall concern
" the Academy, or be relative to the end and deſign of its inſtitu-
" tion ; and ſhall have power and authority from time to time
" to break, change, and renew the common ſeal, at their pleaſure ;
" and that they may ſue and be ſued in all actions, real, perſonal
" and mixed, and proſecute and defend the ſame unto final judg-
" ment and execution, by the name of, The Preſident and
" Fellows of the *American* Academy of Arts and Sciences.

" *And be it further enacted by the authority aforeſaid*, That the
" Fellows of the ſaid Academy may from time to time elect ſuch
" perſons to be Fellows thereof, as they ſhall judge proper ; and
" that they ſhall have full power and authority from time to time,
" to ſuſpend, expel or disfranchiſe, any Fellow of the ſaid Acade-
" my, who ſhall by his conduct render himſelf unworthy of a
" place in that body, in the judgment of the Academy ; and alſo
" to ſettle and eſtabliſh the rules, forms and conditions of election,
" ſuſpenſion, expulſion and disfranchiſement. *Provided*, That the
" number of the ſaid Academy, who are inhabitants of this State,
" ſhall not, at any one time, be more than two hundred, nor leſs
" than forty.

" *And be it further enacted by the authority aforeſaid*, That the Fel-
" lows of the ſaid Academy ſhall have full power and authority
" from time to time, to make and enact ſuch reaſonable rules, or-
" ders and bye-laws, not repugnant to the laws of this State, as
" ſhall be neceſſary or convenient for the well ordering and good
" government of the ſaid Academy ; and to annex reaſonable pe-
" cuniary fines and penalties to the breach of them, not exceeding
" the ſum of *twenty pounds*, to be ſued for and recovered in any
" Court of record within this State, in the name and for the uſe
" of the Preſident and Fellows of the ſaid Academy ; and the
" ſame rules, orders and bye-laws to repeal at their pleaſure : And
" alſo to ſettle and eſtabliſh the times, places, and manner of con-
" vening the Fellows of the ſaid Academy : And alſo to deter-
" mine the number of Fellows which ſhall be preſent, to conſti-
" tute a meeting of the ſaid Academy. *Provided*, That the Fel-
" lows of the ſaid Academy ſhall meet twice in a year at the leaſt ;
" and

" and that the place of their meeting shall never be more than
" thirty miles distant from the town of *Boston*.

" *And be it further enacted by the authority aforesaid*, That the Fellows of the said Academy may, and shall forever hereafter be " deemed capable in the law of having, holding, and taking in " fee-simple, or any less estate, by gift, grant, devise or otherwise, " any lands, tenements, or other estate, real and personal: *Provided*, " That the annual income, of the said real estate, shall not exceed " the sum of *five hundred pounds*, and the annual income or interest " of the said personal estate shall not exceed the sum of *two thousand* " *pounds*. All the sums aforementioned in this act to be valued in " silver, at the rate of *six shillings and eight-pence* by the ounce. And " the annual interest and income of the said real and personal estate, " together with the fines and penalties aforesaid, shall be appro- " priated for premiums to encourage improvements and disco- " veries in agriculture, arts and manufactures, or for other pur- " poses, consistent with the end and design of the institution of the " said Academy, as the Fellows thereof shall determine.

" *And be it further enacted by the authority aforesaid*, That the " end and design of the institution of the said Academy is, to pro- " mote and encourage the knowledge of the antiquities of *America*, " and of the natural history of the country, and to determine the " uses to which the various natural productions of the country " may be applied; to promote and encourage medical discoveries, " mathematical disquisitions, philosophical enquiries and experi- " ments; astronomical, meteorological and geographical observa- " vations; and improvements in agriculture, arts, manufactures " and commerce; and in fine, to cultivate every art and science, " which may tend to advance the interest, honor, dignity and " happiness of a free, independent and virtuous people.

" *And it is further enacted*, That the place where the first meeting " of the Fellows of the said Academy shall be held, shall be the " Philosophy Chamber in the University of *Cambridge*; and that the " Honorable *James Bowdoin*, Esq; be, and he hereby is authorised " and empowered to fix the time for holding the said meeting, " and to notify the same to the Fellows of the Academy."

Such is the basis, upon which this institution is placed.

Not many months after this act of incorporation was passed, the statutes were formed, the body became organized, and communications were received. From the communications till the end of the year 1783, the following volume is now offered to the public. This

This country being young, and few among us having ſuch affluence and leiſure as to admit of their applying much time to the cultivation of the ſciences, and to the making of improvements in arts, manufactures, agriculture, &c. it will not, at preſent, be expected, that this Academy ſhould vie with ſimilar inſtitutions in old countries, where they have peculiar advantages for ſuch proſecutions. Yet, it is hoped, that the following papers will not be reckoned uſeleſs, nor prove unacceptable to the public.

The aſtronomical and mathematical papers, in this volume, will, perhaps, be the leaſt entertaining of any in the collection, and will have the ſmalleſt number of readers. However, they are uſeful in ſuch a work. Few, if any of them, contain deep ſpeculations and obſtruſe reſearches and calculations; but they are chiefly of the practical kind. The aſtronomical pieces principally exhibit ſuch obſervations and deductions, as are ſubſervient to the cauſe of geography and navigation, the improvement of which is of great importance to this country. And as aſtronomical obſervations may be applied to ends ſo valuable, it is earneſtly to be wiſhed, that every gentleman capable of it, would improve every opportunity to make them with accuracy, and when made, would kindly communicate them to the Academy. Theſe, and all mathematical pieces, will be gratefully received, and due attention paid to them, by this body.

To ſome readers, the ſubject of many papers, which have a place in the phyſical part, may ſeem unimportant; but it ought to be remembered, that one intereſting purſuit of the Academy is the natural hiſtory of their own country;—a country, where the arts of defence and the means of ſubſiſtence have, hitherto, almoſt engroſſed the induſtry of its inhabitants; where the foſſil and vegetable kingdoms are yet unexplored, and perhaps, their moſt valuable productions ſtill undiſcovered.

It is the part of a patriot-philoſopher to purſue every hint—to cultivate every enquiry, which may eventually tend to the ſecurity and welfare of his fellow citizens, the extenſion of their commerce, and the improvement of thoſe arts, which adorn and embelliſh life. Nor can ſuch traces and veſtiges, as may occur, of the manners and reſources of its aboriginal inhabitants, be unworthy the collection. Beſides the idea thus excited of the condition of man in ſavage life, the preſent inhabitants of the ſame climate and ſoil may thereby, in ſome way or other, occaſionally receive hints, which may be improved to their own advantage. This principle, which has governed

ed the Academy in making the selection, will account for the introduction of some articles, relating to the natural history of the country.

Many pursuits, in various branches of natural philosophy, are retarded, by the difficulty of obtaining that variety of instruments, which can be had only from those countries, where the manufactures, which minister to the arts, are established in perfection. But this difficulty, it is hoped, will daily lessen, and ere long, entirely cease.

The medical papers may, probably, contain many observations not entirely new. However, this ought not to be considered a sufficient objection to their being inserted in this work, because many important discoveries in pathology, as well as in the animal œconomy, have been in a great measure useless to this part of the world, in consequence of a situation so remote from ancient seats of learning and improvement. And of such publications as have reached this country, the smallness of the number has greatly limited their usefulness, as but few have had opportunity for perusing them. In points merely speculative, this inconvenience has been less consequential; but, in practical science, deeply to be regretted. A long war, in which these States were engaged, destroyed, for a time, that intercourse, by means of which, books on the various arts and sciences, and such as contained the most modern discoveries and improvements, had usually been obtained. The contents of some of these papers, therefore, though they may afford nothing new to the *European*, yet, to many *American* readers may have the recommendation of novelty.

It may be further remarked, that although the novelty of an opinion or discovery may, sometimes, more advance the fame and honour of the author, yet, that there are known facts, of such a nature, that the repetition of them, in publications of this kind, may be no less useful to the world, as they may thereby be more forcibly impressed upon the mind, and conveniently adverted to, in common practice.

Upon these principles the Academy conceived it to be their indispensible duty to publish, by means best adapted to the purpose of diffusing their utility, such experiments and observations, as, though not new, yet, not having been sufficiently attended to, may be more extensively applied towards perfecting the present modes of practice in this country, as well as to communicate, by the earliest opportunities, such discoveries, as may lead to the investigation of important phenomena, in the animal œconomy.

It is obvious that the following work is well calculated for anſwering theſe intentions. The circulation of it will be principally confined to theſe States; and as a repoſitory of miſcellaneous papers on the ſubject of phyſic and ſurgery, it will, doubtleſs, generally fall into the hands of gentlemen of the faculty in this country; a circumſtance, which will very rarely take place, with reſpect to any publication imported from abroad.

The Members of the Academy are diſpoſed to do every thing in their power to promote the deſigns of the inſtitution; but they are ſenſible, that much aid is wanted from others; and they are happy to have it in their power to acquaint the public, that from the number of valuable communications, which have been made by gentlemen in various parts of the country, there is reaſon to expect, that their aſſiſtance will be continued, and ſuch materials furniſhed, as will not be unworthy the notice of the public, which it is the ſincere wiſh of the Academy to ſerve. And from that expectation, and the great encouragement given to the printing of this volume, they have the pleaſing proſpect, that they ſhall be able to publiſh a ſucceſſion of volumes. The papers they now have in their hands will go a conſiderable way towards another; and they doubt not, they ſhall ſoon have ſufficient to complete it.

There is now an ample field opened, in this country, in which the ingenious may expatiate; and men of various turns of mind may employ their leiſure, not only to their own amuſement and improvement, but alſo to the emolument of the community.

Agriculture ſtands in great need of attention. As the ſolid proſperity of the country will much depend upon the cultivation of our lands, too much regard cannot be paid to this ſubject. To examine the various ſoils, and determine what each is beſt adapted to produce; to aſcertain the moſt ſuitable manures, and the means of increaſing them; to deviſe methods to ſecure the fruits of the field, and of the trees from blights and deſtructive inſects, will afford a fine opportunity for experiments, which, it is hoped, will engage the minds of the curious and inquiſitive, and meet with encouragement from gentlemen of property.

The genius for natural hiſtory may have a large range, as the foſſil, the vegetable and animal kingdoms, in this part of the world, lie before him.

There will be ample room for the reſearches of the Botaniſt and Chymiſt, who, while they purſue their reſpective branches, may greatly contribute to the advancement of the healing art, which is of the higheſt importance to the inhabitants of a country.

The

The labors of the Aſtronomer are much needed; and will be peculiarly uſeful,—particularly thoſe obſervations and calculations, which will ſerve to perfect the geography of the country, and improve navigation, as has before been intimated. Hereby, the boundaries between one State and another in the Union, may be accurately determined, and diſputes prevented or ſettled; the latitudes and longitudes of our ſea-ports and head lands aſcertained, and our intercourſe with foreign nations facilitated.

The various mechanical arts and manufactures, together with commerce, require peculiar attention and cultivation; and much may be expected, from that ſpirit of enterpriſe, which our citizens are known to poſſeſs. Happily, they who are engaged in theſe ſeveral branches of buſineſs may mutually aid each other; and every improvement they make, will tend to enrich and aggrandize theſe confederated States.

But this preface would far exceed the proper limits, ſhould all thoſe branches of buſineſs and of ſcience be pointed out, which ought to be attended to and cultivated, by the inhabitants of theſe States. Let it only be added, that, ſettled in an extenſive country, bordering upon the ocean, and open to a free intercourſe with all the commercial world—A country comprehending ſeveral climates and a rich variety of ſoils, watered and fertilized by a multitude of ſprings and ſtreams, and by many grand rivers, ſome of them admitting of a fine inland navigation,—the citizens have great opportunities and advantages for making uſeful experiments and improvements, whereby the intereſt and happineſs of the riſing empire may be eſſentially advanced. At the ſame time, enjoying, under a mild but ſteady government, that freedom, which excites and rewards induſtry, and gives a reliſh to life—That freedom which is propitious to the diffuſion of knowledge, which expands the mind, and engages it to noble and generous purſuits,—they have a ſtimulus to enterpriſe, which the inhabitants of few other countries can feel. May they ever be as virtuous and induſtrious as they are free! May a ſpirit for advancing every kind of knowledge, that can redound to their honor, and promote the emolument and happineſs of themſelves and their country, more and more prevail! And may all their laudable endeavors, to further the good of mankind, be crowned with ſucceſs adequate to their higheſt wiſhes!

November 16, 1785.

STATUTES

OF THE

AMERICAN ACADEMY OF ARTS AND SCIENCES.

CHAPTER I.

Of Officers, and the manner of their election.

1. THERE shall be a President, one Vice-President, ten Counsellors, two Secretaries, a Treasurer, a Vice-Treasurer, and a Keeper of the Cabinet: which officers shall be annually elected by written votes on the day next preceding the last Wednesday in May.

2. In order to this election, the President, or in his absence the Vice-President, or in the absence of the President and Vice-President, the senior Counsellor present shall take the chair, at three o'clock, P. M. and after the choice of three scrutineers by nomination, the ballot shall begin and remain open till five o'clock, at which time it shall be closed; upon which, should it appear in any instance that there is no choice, the balloting shall be renewed till a choice is made.

3. Each Elector shall deliver his balloting list, folded, to the President, and a scrutineer, sitting by the President with a list of the Members of the Academy present before him, shall mark the name of each person so delivering in his list.

4. When the ballot is closed, the scrutineer shall sort the votes, and report the same to the chair; after which, the presiding member shall declare the persons, who have the majority of votes, to be the officers respectively for the ensuing year.

5. If either of the Secretaries, the Treasurer, or the Keeper of the Cabinet die, resign, or be removed during the year, at the next meeting of the Academy the vacant office or offices shall be filled by written votes for the remaining part of the year.

6. At

6. At all elections of officers, if the suffrages should be equal, the decision shall be by lots prepared by the scrutineers, and drawn by the President.

7. Notwithstanding the election of officers be annual, the Academy reserve to themselves a power of removing any of them for neglect of their trust, or disobedience to the orders of the Academy.

8. A Messenger may be appointed or removed at any meeting of the Academy.

CHAP. II.

Of the President and Vice-President.

1. THE business of the President, or in his absence of the Vice-President, or in the absence of the President and Vice-President, then of the senior Counsellor present, shall be to preside in the meetings, and to regulate the debates of the Academy and Council; to state and put questions both in the affirmative and negative, according to motions regularly made; to call for reports and accounts from Committees and others; to preserve decorum; to summon all meetings of the Council, and all extraordinary meetings of the Academy, by advice of Council, upon any urgent occasions; and to execute or to see to the execution of the statutes of the Academy.

2. The President, or in his absence the Vice-President or presiding Counsellor, is empowered to draw upon the Treasurer for such sums of money as the Academy shall direct.

CHAP. III.

Of the Council.

1. THE Council shall have full authority, and it is their incumbent duty, from time to time, to originate such laws, statutes, orders and constitutions, as shall appear to them to be necessary or useful, according to their judgment and discretion, for the regulation, government, and promotion of the design of the Academy: all which laws, statutes, orders and constitutions, shall be by them presented at a meeting of the Academy for the approbation of the Fellows; also to prepare such other matters as they may judge proper to be pursued by the Academy, in order to advance in the best manner the end of its institution. Nevertheless, no Fellow is

hereby

hereby precluded from laying before the Academy ſuch matters, or propoſing ſuch laws, as he ſhall think conducive to its benefit.

2. The Council, with the Preſident and Treaſurer, have power to make concluſive bargains for real or perſonal eſtate, for the benefit of the Academy, and to rent the ſame, and to give orders concerning the improvement of the eſtate, goods, lands and revenues of the Academy, purſuant to the orders of the Academy.

3. Every deed or writing to which the common ſeal is to be affixed, ſhall be paſſed and ſealed in Council, and ſigned by the Preſident, and four, at the leaſt, of the Council.

4. During the receſſes of the Academy, the Council ſhall direct the Secretaries in ſuch correſpondence as they ſhall find expedient. The whole of which ſhall be laid before the Academy at its next meeting.

5. The Council ſhall order ſuch papers and letters to be recorded as they ſhall think proper.

C H A P. IV.

Of the Secretaries.

1. ONE of the Secretaries ſhall have the charge and cuſtody of the Charter and Statute-Book, Journal-Books, Regiſter-Books, and all literary papers belonging to the Academy; and alſo all letters, after they have been recorded, ſhall be kept by him on file. This Secretary, if poſſible, ſhall attend at all meetings of the Academy and Council, where, when the preſiding member hath taken the chair, he ſhall read the orders and entries of the laſt precedent meeting, and ſhall take notes of the orders and tranſactions of the preſent meeting, to be entered by him in the reſpective books, to which they relate. And when there ſhall be a competent number for making elections, he ſhall give notice of any candidates that ſhall ſtand propounded in order to election into the Academy.

2. The other Secretary ſhall have the charge and cuſtody of the letter-books belonging to the Academy. He ſhall attend all meetings of the Academy and Council, and read all letters ſent to the Academy, or to any member in his academical capacity, and draw up all letters to be written to any perſons in the name of the Academy or Council (to be read and approved of in ſome meeting of either, reſpectively) except for ſome particular cauſe and conſideration, ſome other perſon or perſons be appointed by the Academy

or

or Council, to draught any ſuch letter. He ſhall alſo enter all letters that ſhall be directed by the Academy or the Council, and when entered, the originals ſhall be delivered to the firſt-mentioned Secretary in order to their being filed.

3. At every meeting of the Academy, the Secretary, in whoſe cuſtody the letter-books are, ſhall read any entries that the preſiding member ſhall direct; and the Secretary, in whoſe cuſtody the originals are, ſhall have with him, ready to produce, the file of all letters received ſince the laſt precedent meeting, that, if it be required, a compariſon may be made.

4. Each Secretary ſhall deliver an atteſted copy of any tranſaction of the Academy, or paper belonging to his particular department, to any member, upon his producing a written licence from the Council for that purpoſe; and to any other perſon, who ſhall produce a licence from the Academy ſigned by the preſiding member, and in no other caſe whatever.

5. Whenever any copy ſhall be delivered by a Secretary, the perſon, upon receiving it, ſhall pay him ſuch fees as the Academy may eſtabliſh.

CHAP. V.

Of the Treaſurer and Vice-Treaſurer.

1. THE Treaſurer and Vice-Treaſurer ſhall give ſuch ſecurity as the Academy ſhall require for the truſt repoſed in them reſpectively.

2. The Treaſurer ſhall receive officially all monies or ſums of money due or payable, and all bequeſts and donations that may be made to the Academy: and by order of the Preſident or preſiding member, ſhall pay ſuch ſums as the Academy or the Council ſhall direct, purſuant to the orders of the Academy, and ſhall make no diſburſements of money otherwiſe, and ſhall keep a particular account of ſuch orders, receipts, and payments.

3. All monies or ſums of money whereof there ſhall not be preſent occaſion for expending, or diſpoſing to the uſe of the Academy, ſhall be put out to intereſt on ſuch ſecurities, or otherwiſe diſpoſed of as the Academy, or the Preſident and Council, purſuant to the orders of the Academy, ſhall direct.

4. The Treaſurer's accounts ſhall be annually audited by a Committee appointed by the Academy for that purpoſe. In which appointment not more than one member of the Council ſhall be included.

5. In

5. In cafe of the death, refignation or removal of the Treafurer, the Vice-Treafurer is empowered to receive all books, papers, and effects, that were in the cuftody of the Treafurer, and which belong to the Academy, and to give receipts and difcharges for the fame in the name of the Academy. A duplicate of which figned by the Vice-Treafurer fhall be filed with the Prefident. The fame procefs fhall be obferved upon the choice of a new Treafurer, and his acceptance of the office.

CHAP. VI.

Of the Keeper of the Cabinet.

1. THE Keeper of the Cabinet fhall receive and have in his charge and cuftody, all productions of nature and works of art, that fhall be purchafed by, or prefented to the Academy. He fhall arrange them according to their refpective claffes in natural hiftory, philofophy, &c. at his own difcretion; unlefs he be directed therein by a Committee of the Academy for that purpofe. He fhall alfo, in a book, to be kept by him, regifter the various articles in claffes correfponding to the arrangement of the Articles themfelves, with the defcription that may accompany the article, the donor's name, and the place whence taken; and the time when prefented.

2. He fhall attend the exhibitions of the articles in his cuftody, whenever the Academy fhall meet; and no perfon fhall be admitted to a view of them at any other time, unlefs in prefence of the Keeper of the Cabinet, or fome member appointed by the Council for that purpofe.

3. He fhall be Librarian to the Academy 'till they fhall judge it expedient to appoint a diftinct perfon to that office.

4. He fhall give fuch fecurity as the Academy fhall judge proper for the faithful difcharge of his office, and for furrendering the articles in his cuftody, whenever required by the Academy.

CHAP. VII.

Of the Meetings of the Academy and Council.

1. THERE fhall annually be four ftated meetings of the Academy, viz. On the laft Wednefday in *January*, and the day next preceding the laft Wednefday in *May*, at *Bofton*, and on the

Wednefday

Wednesday next preceding the last Tuesday in *August*, and the second Wednesday in *November* at the University in *Cambridge*. Provided that in case the President shall at either of the said annual meetings, within the year of his first appointment, think proper to deliver, before the Academy, an inaugural oration or philosophical discourse, the place of such meeting may be at *Boston* or *Cambridge*, according as it shall be most convenient to him: of which he shall give notice at some preceding meeting of the Academy.—The Council shall also meet four times annually, viz. On the first Wednesday in *January*, and the first Wednesday in *May*, at *Boston*; and on the first Wednesday in *August*, and the third Wednesday in *October*, at *Cambridge*: unless it should by any means be unsafe for the Academy or Council to convene at either of the places above-mentioned, at the times specified. In which case the President with the advice of the Council, may appoint the next stated meeting of the Academy, at any place within thirty miles distance from *Boston*; and the President in the abovementioned case may appoint a meeting of the Council within the above said limits.

2. Extraordinary meetings of the Academy may be called at any time or place within thirty miles distance from *Boston*, by the President with the advice of the Council. And extraordinary meetings of the Council may be called by the President within the aforesaid limits, whenever he shall judge it necessary.

3. Eleven Fellows shall be present to constitute a meeting of the Academy, unless for the purposes of receiving communications, and adjourning, in which cases, seven shall be a quorum. And at any meeting of the Council the presiding member, with four others of the Council, are required to be present, in order to transact any business proper to the Council.

4. At all meetings of the Academy or Council the President, and Vice-President, or in their absence, the presiding member shall have a right to vote in common with the other members of either body respectively.

5. No person shall be introduced to any meeting of the Academy but by vote of the Academy, except *American* and foreign Ambassadors, members of Congress, members of the Supreme Legislative and Executive of the State of *Massachusetts* for the time being, and members of similar institutions with this Academy, who may be introduced by any member of the Academy.

6. All meetings of the Academy ſhall be advertiſed in two at leaſt of the public news-papers, fourteen days previous to ſuch meeting, by one of the Secretaries under direction of the Preſident, or in his abſence of the Vice-Preſident, or preſiding member of the Council.

7. All meetings of the Council ſhall be notified to the ſeveral members by billets from the Preſident, or one of the Secretaries under direction of the Preſident, or in his abſence, of the Vice-Preſident or preſiding member of the Council, ſeven days at leaſt before the time ſtated or propoſed for a meeting.

CHAP. VIII.

Of Fellows.

1. NO perſon ſhall be elected a Fellow of the Academy, unleſs propoſed and recommended by one or more of the members, nor nominated to the Academy until he has firſt been propoſed to the Council, and they have conſented to ſuch nomination; and the name, place of abode, and addition of the perſon recommended, ſhall be delivered in, ſigned by the propoſers, and read by one of the Secretaries. A fair copy of ſuch paper, with the date when delivered, ſhall be hung up in the room, where the Academy ſhall from time to time meet, on which the Candidates may be balloted for at the next, or ſome ſucceeding meeting. And if three-fourths of the Fellows then preſent ſhall ballot in his favor, he ſhall be a member.

2. Each Fellow reſiding in the State of *Maſſachuſetts*, ſhall be ſubject to an annual payment of   *Spaniſh* milled dollars in ſpecie, or an equivalent in bills of the current exchange. Fellows without the State ſhall be ſubject to no other annual payment, than they voluntarily conſent to.

CHAP. IX.

Of Proceedings on literary Performances.

1. THE Academy will never give their judgment or opinion, upon any literary performances preſented to them, but allow it to reſt upon its own merit, and the credit of its author.

CHAP.

CHAP. X.

Of Oaths.

1. THE Prefident, Vice-Prefident, Counfellors, Secretaries, Treafurer, Vice-Treafurer and Keeper of the Cabinet, fhall each take the following oath, *mutatis mutandis* :

I A. B. *elected to the office of*   *in the* American Academy of Arts and Sciences, *do fwear, that I will, according to my beft judgment and difcretion, faithfully difcharge the duties of the truft repofed in me.*

So help me GOD.

An Explanation of the Plate in the title Page.

THE principal figure in it is Minerva. At her right-hand is a field of Indian Corn, the native grain of *America.* The profpect on that fide is bounded by an hill, crowned with Oaks. On the declivity of the hill, towards the fea, appears the out-fkirt of a town, the body of which is concealed by the hill. About the feet of Minerva are fcattered feveral inftruments of hufbandry. On her left-hand are a quadrant and a telefcope, a profpect of the fea, with a fhip fteering towards the town; and the fun rifing, and appearing compleatly above the cloud, in which it rofe. Over the whole, the motto SUB LIBERTATE FLORENT.

The device reprefents the fituation of a new country, depending principally on agriculture : but attending at the fame time to arms, commerce, and the fciences. The fun above the cloud reprefents, not only our political ftate in 1780, when the Academy was firft incorporated, but alfo the rifing ftate of *America*, in regard to empire, and the arts and fciences.

The motto conveys the general idea, that arts and fciences flourifh beft in free States.

A
L I S T
OF THE
AMERICAN ACADEMY OF ARTS AND SCIENCES,
M,DCC,LXXXV.

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ADVERTISEMENT.

AS the Academy is possessed of a number of valuable papers, which would go far towards forming another volume, it is requested of their Brother-Members, both foreign and domestic, and of gentlemen in general, that they would favour the Academy with their communications upon any subjects, that fall within the design of the institution. In case of their being thus favoured, they will, in a short time, publish proposals for printing a second volume of Memoirs.

PRESENTS

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AMERICAN ACADEMY OF ARTS AND SCIENCES;

WITH THE NAMES OF THE DONORS.

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Rev. DAN. FULLER.	Indian utensils, viz. a stone-ax, and gouge. See plate III. fig. A. and C.
JON. TITCOMB, *Esq*;	An Indian stone-pipe, having 13 notches on one and 11 on the other side of the stem. Those on one side, according to tradition, express the number of enemies slain; and those on the other side denote the number of prisoners actually taken by the proprietor. See plate III. fig. 13.

Mr.

DONORS.	
Mr. D. WATSON.	An emblematical ſtone, found two feet below the ſurface of the earth, ſuppoſed to be wrought by the Aboriginals. See plate III. fig. E.
Mr. CROCKER.	A clayey luſus naturæ, repreſenting a piſtol, found in *Hudſon's-River.* See plate III. fig. D.
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Various other articles have been preſented, chiefly foſſil ſubſtances. Theſe, with the donors, may be particularly noticed in a future publication; when, after being properly aſſayed, a more ſatisfactory account may be given of them than can be at preſent.

A
PHILOSOPHICAL DISCOURSE,

PUBLICKLY ADDRESSED TO THE

AMERICAN ACADEMY OF ARTS AND SCIENCES,

In Boston, *on the eighth of November,* M,DCC,LXXX : *when the* PRESIDENT *was inducted into Office.*

BY JAMES BOWDOIN, ESQUIRE,

PRESIDENT *of the* ACADEMY.

GENTLEMEN *of the* AMERICAN ACADEMY *of* ARTS *and* SCIENCES!

WHEN I conſider, that among the members of the Academy there are gentlemen of abilities ſuperior to my own, eſpecially in the walks of philoſophy, I feel a conſciouſneſs, that its honours might in one inſtance have been better placed. But if a defect of abilities could be compenſated by a good will to ſerve its intereſt, and promote the end of its inſtitution, I ſhould have the ſatisfaction to think myſelf not wholly unqualified for the ſtation, with which your ſuffrages have honoured me.

It is in diſcharge of the duties of it, that I appear in this place: and in the diſcharge of them, both at preſent and on future occaſions, as I greatly need it, ſo I doubt not I ſhall always experience your candour :—the candour, which ever accompanies generous minds, and is the reſult of the due exerciſe of the ſocial affections.

The ſocial affections in man are the principal ſource of his

N.B. At the deſire of the Academy, expreſſed by their vote of the 8th of November, 1780, this Diſcourſe was ſoon after publiſhed.

happineſs; and the operation of them, as directed by his wants, and other circumſtances, forms his connections in ſociety. Their firſt objects, in the order of nature, are our relations and near friends; next to theſe our neighbours and countrymen ſucceed; then the people of other countries, in political connection with us; and in the laſt place, mankind in general. In proportion, however, as theſe objects are more remote, thoſe affections are the leſs powerful. After operating on their firſt objects in our family connections, and carrying us to the vicinity, they are drawn forth more particularly to ſuch individuals as diſcover a likeneſs to ourſelves in genius and diſpoſition; and appear to have intereſts co-incident with our own. The acquaintance thus begun, ſtrengthens and improves by time; and the pleaſure and mutual benefits, reſulting from it, prompt us to continue and enlarge it. Theſe ſocial circles increaſe with population, and at length occaſion the eſtabliſhment of ſocieties, more effectually to ſecure thoſe benefits, and render them permanent. But the ſocial principle is of a nature ſo active and comprehenſive, that it leads mankind to aſſociate in larger bodies; and to eſtabliſh great communities, in which the ſtrength and abilities of individuals being united and conſolidated, each individual perſonally, as well as the community at large, may enjoy the ſecurity, and advantages reſulting from that union.

Hence have originated government, and the various political connections, ſubſervient and neceſſary to it. Hence, amidſt a variety of others of different kinds, have ſprung the numerous inſtitutions for promoting philoſophical knowledge, and inveſtigating the works of nature: among which, ſome in *Europe*, and in particular, the Royal Academy of Sciences at *Paris*, and the Royal Society of *London*, bear a diſtinguiſhed character.

Hence

Hence too, the ſocieties of a ſimilar nature, which begin to adorn *America*; particularly the Philoſophical Society at *Philadelphia*, whoſe firſt eſſays, ſo ingeniouſly executed, are received by us as a pledge for ſtill nobler productions. It is hoped they will excite in this new-formed ſociety, a generous ardour and emulation in the ſame laudable purſuits; and that, as optic glaſſes, by collecting the ſolar rays, do aſſiſt and ſtrengthen the corporeal ſight, ſo the two ſocieties, by concentering in a proper focus the ſcattered rays of ſcience, may aid and invigorate the intellectual: benefiting by their productions, not only the communities in which they are reſpectively inſtituted, but *America* and the world in general: both together reſembling ſome copious river, whoſe branches, after refreſhing the neighbouring region, unite their waters for the fertilizing a more extenſive country.

The end and deſign of inſtituting this ſociety are fully declared in the act of the legiſlature for its incorporation: namely, "to promote and encourage the knowledge of the antiquities of *America*, and of the natural hiſtory of the country; and to determine the uſes, to which its various natural productions may be applied: to promote and encourage medical diſcoveries; mathematical diſquiſitions; philoſophical enquiries and experiments; aſtronomical, meteorological, and geographical obſervations; improvements in agriculture, arts, manufactures and commerce; and, in fine, to cultivate every art and ſcience, which may tend to advance the intereſt, honour, dignity and happineſs of a free, independent, and virtuous people."

Here is opened a wide and extenſive field, which the ſons of literature are invited to cultivate and improve: a field of the richeſt ſoil, ſo varied in its qualities, as to be adapted to every mode

mode of cultivation. Here they will find abundant matter for the employment of their induſtry; and the moſt ample room for the exerciſe of their genius, in its utmoſt power of expanſion.

Here they are directed to the fountain-heads of ſcience, at which they are invited to recreate themſelves; and of whoſe delicious waters they may drink without the danger of intoxication: or in caſe of danger, contrary to the effect of ſome other waters, it diminiſhes in proportion to the largeneſs of the draught: as intimated in the elegant lines of a well-known poet.

" A little learning is a dangerous thing:
Drink deep, or taſte not the pierian ſpring.
There ſhallow draughts intoxicate the brain;
And drinking largely ſobers us again."*

We ſhall now take a curſory view of ſome of the ſubjects, which are to employ the enquiries and reſearches of this ſociety; and which we ſhall notice in the order obſerved in the act for incorporating it: making, in our progreſs, a few obſervations, that naturally reſult from them.

The antiquities of *America*, † are the firſt mentioned.—A knowledge in the antiquities of a country neceſſarily implies a knowledge of its antient hiſtory; and the reſearches into them lead directly to the ſource and original of things.

It

* *Pope*'s eſſay on criticiſm.

† *Salve, magna parens frugum, Veſputia tellus,*
Magna virum: tibi res antiquæ laudis et artis
Ingrediar, ſanctos auſus recludere fontes.
VIRG: GEORG: 2.

The *American Academy* is here perſonated; and the *res antiquæ laudis, &c.*—are to be conſidered as ſubjects of their future enquiry.

The compliment paid to our country by ſubſtituting *Veſputia* for *Saturnia*, it is hoped, will be as juſtly applicable to it as *Virgil*'s was to *Italy*.

It is very pleasing and instructive—to recur back to the early ages of mankind, and trace the progressive state of nations and empires, from infancy to maturity, to old age, and dissolution:—to observe their origin, their growth and improvements, their different governments and laws, their variant customs and religion:—to observe the progress of the arts among them, which at first were few and rude, suggested by their wants and necessities, but gradually increasing in number and perfection, in proportion to the enlargement of the community, and as the culture of them was encouraged:—to observe the rise and gradual advancement of civilization, of science, of wealth, elegance, and politeness, until they had obtained the summit of their greatness:—to observe at this period the principle of mortality, produced by affluence and luxury, beginning to operate in them: manifesting itself with greater or less vigour in a variety of ways; and finally terminating in their dissolution, brought upon them by the vices attendant on luxury. Debilitated by these, and incapable of defending themselves against a vigorous invasion, their more hardy neighbours, invited by that circumstance, and perhaps irritated by the insolence, which national affluence and luxury inspire, invaded and subjugated them. In fine—to observe, after this catastrophe, a new face of things; new kingdoms and empires rising upon the ruins of the old; all of them to undergo like changes, and to suffer a similar dissolution.

Of these events ancient history exhibits the most convincing and instructive evidence: particularly the history of the four great empires, the *Assyrian*, the *Persian*, the *Macedonian*, and the *Roman*: which, like their founders, have long ago, suffered the fate incident to every thing human.

The

The knowledge of theſe events is ſo intimately connected with the knowledge of antiquities, that it is derived from the ſame ſource. Such too is the connection between ancient hiſtory and antiquities, and ſuch the mutual aſſiſtance afforded to each other, that as, on the one hand, ancient hiſtory illuſtrates and explains antiquities, ſo, on the other, antiquities ſerve to verify and authenticate ancient hiſtory, or to correct its errors: and they ſometimes give us a knowledge, or intimation of things, not recorded in hiſtory. Antiquities are alſo incidentally beneficial, by means of the political and other uſeful knowledge, reſulting from the diſquiſitions neceſſary to explain them.

With reſpect to *America*,—there may be many things of *European* extraction, that come under the name and deſcription of antiquities. So far as relate to general laws, cuſtoms and religion, they are, for the moſt part, homogeneous with what took place in the ſame age, and in the countries, from which the firſt *European* coloniſts emigrated; and it is probable they may be learnt, or explained, by the general or antiquarian hiſtory of thoſe countries. Theſe things, together with what was peculiar to thoſe emigrants, and worthy of notice, if not already recorded in *American* hiſtory, will, with other remains of antient times, be proper ſubjects of our enquiry.

Whatever relates to the aboriginal natives of *America*, not already noticed in hiſtory, may be comprized in a very narrow compaſs. Their want of civilization, and improvement, and in particular their total want of literature, by which the ſmall degree of knowledge they acquired by experience, might have been tranſmitted to ſucceeding generations, will juſtify the the opinion, that the preſent race of them, in manners and conduct, differ very little from their anceſtors, who lived centuries ago: excepting in ſome few particulars, occaſioned by their

their intercourse with foreigners. It may naturally be conjectured therefore, that the ancient and modern history of these people, with the exception of what might regard their wars, would appear but little more than a transcript of each other; and that it would be in vain to search among them for antiquities.

It is not improbable however, there may be many ancient historical records, and other valuable remains of antiquity, both *American* and *European*, in the possession of descendants from families, which first settled *America*; and of other persons upon this continent. It were to be wished, that gentlemen possessed, or knowing, of such remains, or of any kind of collections likely to contain such, would cause them to be examined; and if they tend to elucidate, enlarge, or correct history; or in any other way can be beneficial to the public, that they would have the goodness to communicate to this society some account of them: which, at the same time it will characterize them benefactors to the public, will entitle them to the thanks of the society.

The subject next mentioned in the act is natural history.—The society are to encourage the knowledge of the natural history of the country, and to determine the uses, to which its various natural productions may be applied.

Natural history is a copious subject, or rather it includes a very great variety of subjects. The several classes of animals, vegetables, minerals and fossils—in short, every thing produced by nature, whether in the earth, the sea, or air, inclusive of these, are within its department.

The knowledge of it is so necessary to the good of mankind, that it has been cultivated in its several branches, perhaps more than any other part of science; and in proportion to that cultivation,

vation, the properties and qualities of things, and their fitneſs for certain uſes, have been diſcovered. This diſcovery has occaſioned the application of them to thoſe uſes; and thoſe have led to others, according as the wants, or the inventive faculties of man have directed. Hence we have derived the conveniences and ornaments of life, and every improvement in the arts of living.

At firſt however, at the origination of man, when it was indiſpenſibly neceſſary he ſhould be ſupplied with the means of ſubſiſtence, before he had acquired ſufficient knowledge and ability to provide for himſelf, his beneficent CREATOR, the firſt and the ſupremely great Naturaliſt, made known to him the nature and qualities of things, and the uſes to which they might be applied, ſo far as man's well-being required; and having provided for that, and endowed him with ſufficient faculties, he was pleaſed to leave him and his poſterity, to the exerciſe of thoſe faculties, for the gaining a further degree in natural knowledge: in proportion to which, and to their improving it to the purpoſes, for which it was adapted, he intended their future accommodations ſhould be. Accordingly, in different nations, from a greater or leſs exertion of equal faculties, or from a happier application of them, we find a greater or leſs degree of natural knowledge and improvements, and a proportionable difference in their reſpective conveniences and accommodations. Hence, with regard to theſe latter, the difference between *Europe* and *Africa*; between the moſt improved, and beſt accommodated, of mankind, and the Hottentots. But if their natural faculties are unequal, collectively taken, as probably is the caſe, the reaſon of that difference will ſtrike us the more forcibly.

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On the ſuppoſition of ſuch inequality, it may in a great meaſure be accounted for, by the operation of natural cauſes: for altho' before the diſperſion of mankind over the earth, which their increaſed numbers made neceſſary, the human faculties, by reaſon of a ſameneſs in ſituation and other circumſtances, might in general be equal, yet in proceſs of time an inequality would probably take place from a change of climate.

Different climates differ greatly in their degrees of heat and cold, as well as in their natural productions. The tendency of immoderate heat is to relax, unbrace, and debilitate the human frame, and thereby diminiſh the powers of the mind as well as body, and indiſpoſe them to exerciſe and application: which indiſpoſition, ſtrengthened by the force of habit, at length becomes inſurmountable.—On the other hand, immoderate cold too much contracts, and gives too great a degree of rigidity to, the fibres, and nervous ſyſtem; and thereby making them leſs ſuſceptible of quick and lively ſenſations, muſt proportionably affect the mind. Hence, in both caſes, an inferiority of intellects. But in climates, duely tempered with heat and cold, where the organs of ſenſe and motion are in due tone, it may be expected, if this theory be true, that mankind will be capable of greater exertions both of mind and body.* It

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* The Baron de *Monteſquieu*, in his *Spirit of Laws*,† where he treats, Of the difference of men in different climates, although he conſiders the effect of climate, more as it relates to the paſſions, than to the underſtanding, ſuppoſes not only that the difference is owing to different degrees of heat and cold; but that in proportion to them the body and mind are leſs or more vigorous.

If this be the caſe, what is ſaid above reſpecting the effect of climates is not wholly juſt: for *there* it is ſuppoſed, that immoderate cold, as well as heat, diminiſhes the vigour of both.

The latter ſuppoſition may, in ſome meaſure, be ſupported by the hiſtory of the people living in the northern parts of *Norway*, *Sweden*, *Ruſſia*, *Lapland*, and *Siberia*, whoſe characters, both as to mind and body, do not give us any exalted idea of the vigour or ability of either.

† Book xiv. chap. 2. *Nugent's* tranſlation, the 2d. edit.

It will not from hence follow, that the exertions of different nations, dwelling in the ſame latitudes and climates, ſhould be equal: for on the ſuppoſition of equality of capacity, there may be a variety of things, on which their exerting it may depend: ſuch as education, religion, government, and other circumſtances, or the appearance of ſome happy genius to inſtruct and direct them: and as theſe ſhould happen to differ and influence them, their exertions would be proportionably different.

By way of illuſtration, * we may inſtance in what has taken place among ourſelves; and aſk, whether the people of theſe United States, whoſe natural capacity, without doubt, equals that of *Europeans* in the ſame temperate climates, would in certain different circumſtances, have oppoſed the unreaſonable claims of *Britain* upon them? Would they, if at all, have exerted themſelves ſo vigorouſly againſt her inſlaving domination, if they had not been educated in the principles of liberty; if their religion, like that of ſome ſects among them, had not allowed them to make uſe of carnal weapons in the defence of their liberty; or if they had lived under a deſpotic government, and believed in the doctrine of paſſive obedience and non-reſiſtand? Or, laſtly, if ſome among them, well ſituated to obſerve the courſe and tendency of *Britiſh* policy, had not alarmed them of their danger?

If all or any of theſe circumſtances had been different from, or contrary to, what have in fact taken place, the advantages derived from climate, in reference to natural capacity, had probably

* At the time of writing this diſcourſe, the fleets and armies of *Britain* were, and long had been, invading us. This circumſtance, together with the extraordinary manner, in which ſhe conducted the war, occaſioned in one or two of the political obſervations, adduced to illuſtrate the ſubject, ſome little poignancy of expreſſion: which, it is apprehended, the occaſion juſtified.

bly been lost; and the world had not been astonished at the noble and unexpected exertions, we so happily made against the power of *Britain* : a power, distinguished for its magnitude, and with which we had to contend under the pressure of the greatest difficulties and discouragements.

One ardent wish will be indulged to me on this occasion, that we may ever deserve to be possessed of freedom and independence; and by deserving them, convince our enemies, that the SUPREME ARBITER of the fate of nations will not suffer *Britain* to wrest them from us. The first of them—freedom—in a constitutional sense, while we remained connected with *Britain*, and until she spurned our repeated prayers to her for its restoration, was the only object of our exertions : and the latter—independence—wholly alien at that time from our inclinations, but now radicated in them, was the necessary effect of her obstinate injustice.

With respect to the Indian tribes of *America*, and the Blacks of *Africa*, if they descended from the same original stock, and are alike affected with the rest of mankind, they will partake of the advantages and disadvantages of climate in common with them : unless it be supposed, that the unexplored cause of the difference of colour may, in any measure, alter the effects of climate. If it doth not alter them, and if all nations in the same latitudes, considered in the gross, have equal capacities, the difference, that on comparison appears between them, must be casual; arising from some certain adventitious circumstances, which take place in some of them, and not in others; and which, as they arise, call those capacities into action, and thereby occasion that difference.

If

If by public encouragement, or by any other means, knowledge in general, and particularly natural knowledge, be ſuppoſed equal in any two or more nations, their different modes of applying it will produce very different effects ; which, taken together in each, may be equally valuable and uſeful : and if thoſe effects come under the names of manufactures, they may be exchanged for each other to mutual benefit, even where the natural materials are the ſame in kind and quality : but where the materials differ in theſe reſpects, the greater muſt be the difference in thoſe artificial productions, and the greater the benefit ariſing from the exchange.

The various productions, natural and artificial, of different countries, and the benefit reſulting from a mutual exchange of them, give riſe to commerce, navigation, and their attendants : in regard of which, the balance of advantage will always be in favour of that people, whoſe ſkill, induſtry, and cheapneſs of labour, enable them to manufacture and export, the greateſt quantity of commodities : whether manufactured from the rough products of their own, or of other countries. And that balance, if the government of ſuch a people be wiſely adminiſtred, will give them a national ſuperiority in riches, influence, and proſperity : which are principal objects with the honeſt and well-informed politician.

With reſpect to the natural productions of this country, they are perhaps as numerous as thoſe of any other : but it doth not appear by any publications on the ſubject, that they have been examined to any great extent : ſo that our natural hiſtory is very imperfect, not only in relation to ſuch productions as we have in common with other countries, but ſuch as are peculiar to our

own.

own. It is apprehended, however, that gentlemen of ingenuity and obſervation, have noticed and deſcribed many of them: and that their ſeveral deſcriptions and collections, brought into one ſtock, properly methodized and claſſed, would make a reſpectable figure; and encourage further examinations and reſearches, in order to our obtaining an extenſive, and well-digeſted body of *American* natural hiſtory. For a purpoſe ſo beneficial in itſelf, and ſo honorary to our country, it is hoped, ſuch gentlemen will favour the Academy with their deſcriptions and collections; and alſo with the reſult of their future reſearches, relative to the ſame ſubject.

Theſe general obſervations, and particularly thoſe concerning man, and the effects of climate, with the exception of ſome few of them incidentally made, come under the head, and are included in the idea, of natural hiſtory.

What has been ſaid of the influence of climate, agrees in part with the doctrine of the celebrated *Monteſquieu*.* So far as it differs from him, it may need apology: but it is ſubmitted to your candour, juſt as it ſtood written before I had conſulted him on that ſubject.

To theſe curſory obſervations on the ſubject of antiquities and natural hiſtory, I muſt here put an end, as I ſhall ſtand in need of the remains of your patience and candour, while I make a few obſervations of a different kind: which, though not neceſſarily connected with the ſubjects, that fall under the conſideration of the Academy, will not be deemed impertinent, or unſuitable to this occaſion.

The inſtituting of this ſociety, and the neceſſity there was, that it ſhould be preceded by ſuch an inſtitution as *Harvard*'s, naturally

* See a foregoing marginal note

naturally carry us back to the early times of this country, when *Harvard-College* was first founded.§

Our worthy ancestors, knowing from their own experience the advantages of a good education, very early, after their coming hither, provided the means of it for their children, and posterity; and that excellent man, Mr. *Harvard*, made a large and generous bequest for that purpose: in consequence of which, the college was founded; and in honour of him, and to perpetuate the remembrance of his generosity, his name was given to it. From that time to the present, it has been productive of the happiest effects; and the influence and benefit of its instruction have been widely felt. Learning and the principles of good morals have been disseminated; the arts and sciences cultivated; and a spirit of freedom and enquiry promoted, and encouraged: in virtue of which, the best foundations have been laid for excellency in the learned professions.

All these have operated in so forcible and extensive a manner, that they have produced the other seminaries in *America*, established for the like noble purposes: so that our ALMA MATER may be justly considered as the remote parent of them all. I say, *our* ALMA MATER, not merely in relation to the members of this society, individually considered, most of whom, from her breasts, drew the nectareous milk of science, but in relation also to the complex body, the society itself: for, by her discipline, and unremitted inculcations, the way has been prepared for philosophical disquisitions, and an examen into the works of nature: without which, or some such preparatory discipline, this society could not have been formed: or being formed, could not have answered the end of its institution.

At

§ *Harvard-College* was founded in the year 1638; and the date of its first Charter was in 1642.

At the ſame time we are acknowledging our obligations to our ALMA MATER, juſtice demands the tribute of gratitude to her benefactors.

Foremoſt among theſe, ſtands the reverend *Harvard*; reverend by his profeſſion, but much more ſo by real worth, and true dignity of character. By his generous bequeſt, and the ſpirit it inſpired, the government was enabled to eſtabliſh the college: which, by reaſon of the low ſtate of the finances of the country, could not have been eſtabliſhed without ſuch aſſiſtance: ſo that he may juſtly be conſidered as the father and founder of the UNIVERSITY; and in that character his memory ſhould be tranſmitted to poſterity.

In the ſame catalogue alſo, the names of *Stoughton*, *Hollis*, *Holden*, *Hancock*, *Boylſton* and *Hearſey*, whoſe vital part is diſencumbered of its earthborn cottage, hold a diſtinguiſhed place. Their noble and public-ſpirited benefactions, with thoſe of other friends and encouragers of ſcience, are at large recorded in the archives of the univerſity; and therefore need not here be ſpecifically enumerated.

Ye diſembodied ſpirits, now "joined to the great majority," if ye are conſcious of what is tranſacting in this place, and will deign to regard it, permit us to expreſs our gratitude to you, ariſing from a ſenſe of the benefits already derived, and which are deriving, to individuals and the public, from your inſtitutions and benefactions.

If divinity and morality—if the knowledge of the Hebrew ſcriptures, and of the oriental and other languages—if mathematics, and natural, and experimental philoſophy—if the medical art, the belles lettres, and literature in general—are beneficial to mankind, ye have not lived in vain: ſince, to promote the know-

ledge

ledge of theſe has been the object of your aim in thoſe inſtitutions; and your aim has been crowned with the moſt happy and extenſive ſucceſs. This has inſured to you, at leaſt in this country, univerſal approbation; and your names will be remembered with honour, ſo long as literature ſhall be eſteemed, or any veſtige of it remain here.

Though wrapt in the ſhroud of death be your mortal part, ye ſtill live, and through ſucceſſive generations may ye continue to live, in the grateful breaſts of your lettered ſons.—Conſecrated to fame, and born on its ſtrongeſt pinions, may your memory reach to the remoteſt ages, expanding as it flies. And when ages ceaſe to roll—when all things ſhall be ingulphed in vaſt eternity—when eternity itſelf ſhall be abſorpt in the ſelf-exiſtence of the DEITY, may ye be bleſſed, as we humbly truſt ye now are, ſupremely bleſſed, with the approbation of HIM, who gave you the means, and the will to do good. In fine, may your virtues, and excellent example, by inſpiring imitation, procure ſuch benefactions to *Harvard-College*, as to make it, in the moſt proper and extenſive ſenſe, an *Univerſity*.

With reſpect to its ſurviving benefactors, I ſhall not attempt to name or characterize them, as the doing it might offend their delicacy, or ſavour of adulation: they will however have the pleaſing ſatisfaction to reflect, that the eulogium on the ſimilar virtues of others, is an eulogium on their own: and a conſciouſneſs of merit will compel them, without hazarding the charge of a vain-glorious appropriation, to apply it to themſelves.

To have ſaid thus much on the ſubject of the college, will not, on this occaſion, be deemed impertinent, as the inſtituting of it was, not meerly conſiſtent with the forming ſuch a ſociety as ours, but neceſſary to precede it; and as the old inſtitution

may

may with propriety be reputed the genuine parent of the new one. Such is the connection between them, and ſuch the dependence of this upon the other, that as moſt of its preſent members are ſons of HARVARD, ſo its future vernacular members will probably, for the moſt part, be ſupplied from the ſame ſtock: at leaſt ſo long as HARVARD's ſons ſhall continue to be diſtinguiſhed for ſcientific accompliſhments: which, it is fervently hoped, will be as long as ſcience, or any trait of it, remains in the world: or as long as nature, the great ſubject of it, endures.

Derived from ſuch a parentage, and animated by the noble example of other philoſophical inſtitutions, may this ſociety contribute its full ſhare to the common ſtock of knowledge; and endeavour, by the moſt generous exertions, to anſwer the valuable purpoſes of its inſtitution.

"Rapt into future times," and anticipating the hiſtory of our country, methinks I read in the admired pages of ſome *American Livy*, or *Thucydides*, to the following effect.

A century is now elapſed ſince the commencement of *American* independency. What led to it, and the remarkable events of the war, which preceded and followed it, have been already related in the courſe of this hiſtory.

It was not to be expected, that our anceſtors, involved as they were in a civil war, could give any attention to literature and the ſciences: but ſuperior to their diſtreſſes, and animated by the generous principles, which liberty and independency inſpire, they inſtituted the excellent ſociety, called *The American Academy of Arts and Sciences*.

This ſociety formed itſelf on the plan of the philoſophical ſocieties in *Europe*, adopting ſuch rules, and principles of con-

duct, as were beſt ſuited to anſwer the end of its inſtitution. Among others, they laid it down as a fundamental principle, that as true phyſics muſt be founded on experiments, ſo all their enquiries ſhould, as far as poſſible, be carried on, and directed by them. This method was ſtrongly recommended by Sir *Francis Bacon*, "a genius born to embrace the whole compaſs of ſcience, and juſtly ſtiled, the firſt great reformer of philoſophy,"* It was adopted by ſucceeding philoſophers, and particularly by the immortal *Newton*, whoſe ſyſtem of philoſophy, founded on the laws of nature, will for that reaſon be as durable as nature itſelf.

Taking theſe great characters for their guide, and influenced by their illuſtrious example, they proceeded on fact and obſervation, and did not admit of any reaſonings or deductions, but ſuch as clearly reſulted from them. This has been the uniform practice of the ſociety: whoſe members, from time to time, having been choſen from men of every country, from every claſs and profeſſion, without any other diſtinction than was dictated by the dignity of their characters, by their morality, good ſenſe, and profeſſional abilities, we find in the printed tranſactions of the ſociety, the beſt compoſitions on every ſubject, within the line of their department. We find in thoſe tranſactions new facts, new obſervations and diſcoveries; or old ones placed in a new light, and new deductions made from them.

They have particularly attended to ſuch ſubjects as reſpected the growth, population, and improvement of their country: in which they have ſo happily ſucceeded, that we now ſee agriculture, manufactures, navigation and commerce, in a high degree of

* *Mallet's* life of Lord Chancellor *Bacon*.

of cultivation; and all of them making ſwift advances in improvement, as population increaſes. In ſhort, they have, agreeably to the declared end of their inſtitution, "cultivated every art and ſcience, which might tend to advance the intereſt and honour of their country, the dignity and happineſs of a free, independent, and virtuous people."

This is demonſtrably evident from the numerous volumes the ſociety have publiſhed of their tranſactions. Theſe volumes are a noble collection of uſeful knowledge; and conſidered together in their miſcellaneous ſtate, ſtrike the mind with a ſplendour, reſembling the galaxy in the heavens, derived from the combined light of countleſs myriads of conſtellations: and like that too, when the ſeveral correſponding parts are viewed in their proper connections, they appear to be parts of a whole; and to conſtitute the moſt uſeful ſyſtems: ſyſtems diſtinguiſhed by their beauty, regularity, and proportion.——Thus far our hiſtorian.

May this prophetic hiſtory be realized by fact, and may the tranſactions of this ſociety juſtify the future hiſtorian, in giving it a character, like the one juſt delineated: or rather, a character deſervedly more exalted.

In the mean time, as the ſociety is formed on the moſt liberal principles, and is of no ſect or party in philoſophy, it wide extends its arms to embrace the ſons of ſcience of every denomination, and whereſoever found; and with the warmth of fraternal affection invites them to a philoſophical correſpondence: and they may be aſſured, their communications will be eſteemed a favour, and duely acknowledged by the ſociety.

I ſhall cloſe this diſcourſe with a ſhort reflection, reſulting from one of the ſubjects we have been conſidering.

When

When we contemplate the works of nature, animate and inanimate, connected with our earth; obſerve the immenſe number and variety of them; their exquiſite beauty and contrivance; and the uſes to which they are adapted:—when we raiſe our view to the heavens, and behold the beauteous and aſtoniſhing ſcenes they preſent to us—unnumbered worlds revolving in the immeaſurable expanſe; ſyſtems beyond ſyſtems compoſing one boundleſs univerſe: and all of them, if we may argue from analogy, peopled with an endleſs variety of inhabitants:—When we contemplate theſe works of nature, which no human eloquence can adequately deſcribe, they force upon us the idea of a SUPREME MIND, the conſummately perfect author of them,—

"*That* univerſal ſpirit, which informs,
"Pervades, and actuates the wond'rous whole."

In compare with whom his works, great and ſtupendous as they are, are "nothing, leſs than nothing, and vanity." But—though annihilated by the compariſon, yet—viewed in themſelves, they powerfully perſuade us to exclaim, in the rapturous and ſublime language of inſpiration, "Great and marvellous are thy works, LORD GOD almighty, in wiſdom haſt thou made them all."

PHILOSOPHICAL MEMOIRS.

PART I.

ASTRONOMICAL AND MATHEMATICAL PAPERS.

I. *A Method of finding the Altitude and Longitude of the nonagesimal Degree of the Ecliptic; with an Appendix, containing Calculations from corresponding Astronomical Observations, for determining the Difference of Meridians between Harvard-Hall, in the University of* Cambridge, *in the Commonwealth of* Massachusetts, *and the Royal Observatories at* Greenwich *and* Paris. *In a Letter from the Reverend* JOSEPH WILLARD, *President of the University, and Corresponding Secretary of the American Academy of Arts and Sciences, to the Honorable* JAMES BOWDOIN, *L. L. D. President of the Academy.*

SIR,

AS the parallaxes of the planets in latitude and longitude come frequently into use, in astronomical calculations, and particularly in deducing the difference of meridians between one place and another, from corresponding observations of

of ſolar eclipſes and occultations of fixed ſtars by the moon, every method which can be diſcovered, to ſhorten the work, or make it more eaſy, muſt be of utility. In calculating theſe parallaxes, it is neceſſary to find the altitude and longitude of the nonageſimal degree of the ecliptic. As I have given ſome attention to this ſubject, I take the liberty, Sir, of encloſing to you a paper, containing a method of finding theſe prerequiſites, different from any that I have happened to meet with, and (to me indeed) taking the whole proceſs together, eaſier, if not ſhorter. It is deduced from a projection which muſt make the method very obvious, to thoſe acquainted with the ſphere and with ſpheric trigonometry. You will find an appendix upon the longitude of Cambridge. If you think proper to communicate the whole to the Academy, you have my conſent.

I am,

with the greateſt reſpect, &c.

Cambridge, Auguſt 4, 1783.

DEFINITIONS.

1. THE right aſcenſion of the mid-heaven is that point of the equator, which culminates, or is in the meridian of any particular place, at a given time, and is found by adding the given apparent time, reckoned aſtronomically, to the ſun's right aſcenſion, calculated for the ſame time. Or, it may be found, by reducing the given apparent time to mean time, and adding it to the ſun's mean longitude. But, if the hours are reckoned according to civil time, we muſt take the difference between the

the apparent given time and noon ; and if it is the forenoon, this difference muſt be ſubſtracted from the ſun's right aſcenſion ; but if it is the afternoon, it muſt be added. If the mean longitude is taken, the mean time muſt be uſed.

2. The nonageſimal degree of the ecliptic is its higheſt point above the horizon, and is 90° diſtant from each point of the ecliptic, where interſected by the horizon. This nonagiſimal point is determined by a perpendicular to the ecliptic, which paſſes through its poles and the poles of the horizon, the altitude of which point is meaſured from the horizon, upon this perpendicular.

PROBLEM.

Given the latitude of a place, the obliquity of the ecliptic, the time of the day, the ſun's true longitude, his right aſcenſion, and conſequently the right aſcenſion of the mid-heaven, to find the longitude and altitude of the nonageſimal degree of the ecliptic.

A GENERAL SOLUTION OF THE FOREGOING PROBLEM.

In plate I. fig. I. let the circle ♋*p*♑L repreſent the ſolſtitial colures ; then, the poles of the equator and of the ecliptic will be in the plane of this circle. Let the diameter E♎Q repreſent a portion of the equator ; ♋♎♑ a portion of the ecliptic ; P, the north pole of the equator ; *p*, the north pole of the ecliptic ; S and L their ſouth poles. Let the arc P*c* S mark the right aſcenſion of the mid-heaven, from the neareſt equinoctial point ; then this arc will repreſent the meridian of ſome place, at a given time, and *c* and *w* will be the culminat-

ing

ing points of the equator and ecliptic. Let the arc bZi represent the latitude of ſome given place; then the point Z, where the arc is interſected by the meridian, is the zenith of the place, at the given time, and is one of the poles of the horizon; the arc HOR is the horizon; the line ZN its axis, and the point N of the axis, where it is interſected by the arc Pc S continued, is the other pole of the horizon, or the nadir. The arc pZL, drawn through the poles of the ecliptic and of the horizon, marks out the longitude of the nonageſimal degree upon the ecliptic at U, the altitude of which, or height above the horizon is VU. Now the arc pZL is perpendicular both to the horizon and the ecliptic, as it paſſes through the poles of each, and as pU is $=$ ZV $= 90°$ and ZU is common to both, take ZU from each, and there will remain pZ $=$ VU the altitude of the nonageſimal degree of the ecliptic. The longitude and altitude of this point, therefore, may be readily found by the ſpheric triangle PpZ, in which are given two ſides and the included angle, viz. ſide PZ $=$ the co-latitude of the given place; the ſide Pp $=$ the diſtance of the poles of the equator and ecliptic $=$ the obliquity of the ecliptic; and the angle pPZ, the value of which may always be determined by the following general rules, which, from diagrams, will appear very obvious.

The right aſcenſion of the mid-heaven being between 270° and 360° or ♋°, and between 0° and 90°, the neareſt equinoctial point is ♈; and in the firſt caſe, angle pPZ is acute, and is found by ſubſtracting 270° from the right aſcenſion of the mid-heaven. In the ſecond caſe, the angle is obtuſe, and is found by ſubſtracting 270° from the right aſcenſion of the mid-

mid-heaven added to 360°, or, which is the ſame thing, by adding the right-aſcenſion of the mid-heaven to 90°.

The right aſcenſion of the mid-heaven being between 90° and 180°, and between 180° and 270°, the neareſt equinoctial point is ♎ ; and in the firſt caſe, angle pPZ is obtuſe, in the ſecond acute, and in each caſe the angle is found, by ſubſtracting the right-aſcenſion of the mid-heaven from 270°. Theſe rules are to be uſed when the latitude of the given place is north ; but when it is ſouth, they muſt be inverted to find the correſponding angles, as will appear evident by a diagram.

From Z, let fall the perpendicular Zx upon the primitive circle : And to know whether the perpendicular, in any caſe, will fall upon the ſide of P next to p, or oppoſite to it, the following rules may be obſerved.

When the right aſcenſion of the mid-heaven is between 180° and 270°, or between 270° and 0°, that is, when angle pPZ is acute, the perpendicular will fall upon the ſide of P next to p ; but when the right aſcenſion of the mid-heaven is between 0° and 90°, or between 90° and 180°, that is, when angle pPZ is obtuſe, the perpendicular will fall upon the ſide of P oppoſite to p.

For the ſide pZ, the altitude of the nonageſimal degree. Radius : Sine co-angle pPZ :: Tangent ſide PZ : Tangent ſide Px. Then, if the perpendicular be on the ſide of P next to p, the difference between Pp and Px will be px ; but if it fall on the ſide of P oppoſite to p, the ſum of Pp and Px will

will be *px*. *px* being found say, Sine co-P*x* : Sine co-*px* :: Sine co-PZ : Sine co-*p*Z.

For angle P*p*Z, or ∠ at the pole of the ecliptic, Sine segment *px* : Sine side P*x* :: Tangent angle *p*PZ : Tangent angle P*p*Z.

When the perpendicular Z*x* falls upon the side of P opposite to *p*, or between P and *p*, the angle P*p*Z is acute; but when it falls beyond *p*, it is obtuse.

By the angle P*p*Z, the longitude of the nonagesimal degree is determined thus:—When the nearest equinoctial point is ♈, substract this angle from ♋ or 3^s, adding 12^s to 3^s, when necessary; the remainder will be the longitude of the nonagesimal degree. If the nearest equinoctial point is ♎, add this angle to ♋ or 3^s, and the sum will be the longitude of the nonagesimal degree.

Let the foregoing general rules be now elucidated by a particular

EXAMPLE.

Required the longitude and altitude of the nonagesimal degree of the ecliptic, at the royal observatory at Greenwich, August 5, 1766, at $5^h\ 29'\ 57''$ P. M. apparent time?

The solar and lunar elements from MAYER's tables.

At $5^h\ 29'\ 57''$ P. M.

The sun's longitude	$4^s\ 13^\circ\ 9'\ 51''$
The obliquity of the ecliptic	$23\ 28\ 18$

The

The latitude of Greenwich	51° 28′ 39″
Reduced to the center, the earth being an oblate ſpheroid	51 14 11
Complement = PZ	38 45 49

For the ſun's right aſcenſion.

Radius				10
: Sine of the co-obliquity of the ecliptic,	66°	31′	42″	9 9624911
:: Tang : ☉'s longitude from neareſt equinoct point,	46	50	9	10 0278498
: Tang : ☉'s right aſcenſion from neareſt point, viz. ♎	44	21	46	9 9903409
Subſtract the above from	180	0	0	
The remainder is ☉'s right aſc. from ♈	135	38	14	

The given time $5^h\ 29'\ 57''$ being reduced to degrees, at the rate of 15° per hour, gives 82° 29′ 15″. Add this to the ſun's right aſcenſion 135° 38′ 14″; the ſum 218° 7′ 29″ is the right aſcenſion of the mid-heaven. This ſubſtracted from 270° according to the rule, leaves 51° 52′ 31″ for angle *p*P*z*.

For ſide *p*Z, the altitude of the nonageſimal degree.

Radius					
: Sine Co	∠*p*PZ	38°	7′	29″	9 7905493
:: Tangent	PZ	38	45	49	9 9047023
: Tangent	P*x*	26	22	10	9 6952516
Subſtract	P*p*	23	28	18	
Remains	*px*	2	53	52	

Sine

	Sine Co	Px	63°	37′	50″	9	9522832
:	Sine Co	px	87	6	8	9	9994443
::	Sine Co	PZ	51	14	11	9	8919475
:	Sine Co	pZ	60	21	48	9	9391086
	Alt. nona. deg. pZ		29	38	12		

For angle Ppz

	Sine	px	2°	53′	52″	8	7037573
:	Sine	Px	26	22	10	9	6475369
::	Tangent ∠pPZ		51	52	31	10	1052425
:	Tangent ∠PpZ		84	53	49	11	0490221
	Obtufe =		95	6	11		

To ♋ =	3ˢ	0°	0′	0″
Add ∠PpZ =	3	5	6	11
The fum is = the long. of nona. deg.	6	5	6	11

By the foregoing procefs it appears, that the longitude of the nonagefimal degree is 6ˢ 5° 6′ 11″, and the altitude 29° 38′ 12″.

APPENDIX.

APPENDIX.

THE aſcertaining of the difference of longitude between various places on the globe, particularly between important headlands and ſeaports, and alſo between places where aſtronomic obſervations are made, to perfect the knowledge of the heavens, and to improve navigation and geography, are very deſirable objects. Obſervations of eclipſes of the moon and of Jupiter's ſatellites have frequently been made uſe of for this purpoſe. When the beginning or ending has been obſerved in two places, the difference in time is the difference of meridians, which may be reduced to degrees, at the rate of 15° per hour. But the earth's ſhadow is ſo imperfectly defined at the moon, that the beginning or ending of a lunar eclipſe cannot be ſo ſatisfactorily determined, that the difference of meridians, deduced from theſe obſervations, can be entirely depended upon. The beginning or ending of the eclipſes of Jupiter's ſatellites can be determined with more preciſion; but ſtill, much depends upon the magnifying powers and the aperture of the teleſcopes, which are made uſe of for the obſervation: nor is the difference of meridians between two places, deduced from theſe obſervations, reckoned accurate, unleſs there is a conſiderable number, both of immerſions and emerſions, to be compared with correſponding ones. Of late years, therefore, obſervations of ſolar eclipſes, of occultations of fixed ſtars by the moon, and of tranſits of the inferior planets over the ſun's diſk, when made under favourable circumſtances, have been moſt ſought for, and uſed, when they could be obtained, for determining differences of meridians. In theſe obſervations, the difference of times is not the difference of meridians,

ridians, but is ſometimes more, and ſometimes leſs, according to the parallaxes. Theſe, therefore, muſt be carefully computed; and the tedioufneſs of the proceſs has, doubtleſs, prevented obſervations of this kind from becoming ſo generally uſeful, as they would otherwiſe have been. But, as the difficulty may appear leſſened, by having the whole operation brought into one view, I now take the liberty of doing it, for the ſake of thoſe who have not made great advances in aſtronomy, ſhould any ſuch meet with this paper. I have taken, for examples, thoſe obſervations which have led to a determination of the difference of meridians between London and Cambridge, and Paris and Cambridge. An accurate determination of this difference may be very uſeful. Hereby, the aſtronomic tables, which have been fitted to the meridians of the celebrated obſervatories of Paris and Greenwich, are made our own, for all the purpoſes of calculation; and our obſervations may be made uſe of, for correcting and improving thoſe tables: And ſhould new ones be conſtructed for Cambridge, the ſame may be accommodated to the European obſervatories.

PROBLEM.

Given the moon's longitude, latitude, horizontal parallax and horizontal ſemi-diameter, together with the altitude of the nonageſimal degree of the ecliptic, and the angle of it's pole, or angle P*p*Z, and conſequently the longitude of the nonageſimal degree, to find her parallax in latitude and longitude, her viſible ſemi-diameter, or ſemi-diameter augmented agreeably to her altitude or zenith diſtance, and the viſible difference of longitude between the ſun and moon?

If

If the procefs be trigonometrical we muft firft find the moon's altitude and parallactic angle.

In plate I, figure I, let the arc *pe*L cut the ecliptic in *e* = the moon's longitude, and let the arc *l a t* mark out her latitude; then the point of interfection of the two arcs at ☽, will be the moon's true place or pofition. Let the vertical arc Z☽N be drawn; then, in the triangle *p*☽Z, the fide Z☽ will be the moon's zenith diftance, or co-altitude, and the angle *p*☽Z her parallactic angle; to find which, there are given two fides and the included angle, viz. the fide *p*Z = the altitude of the nonagefimal degree; the fide *p*☽ = the moon's diftance from *p* one of the poles of the ecliptic = the complement of her latitude, and the angle Z*p*☽ = the difference between the moon's longitude and the longitude, of the nonagefimal degree.

From Z let fall the perpendicular Z*d*, dividing the oblique angled triangle *p*☽Z into two right-angled triangles, right-angled at *d*.

For fide Z☽ the moon's zenith diftance.

Radius : Sine Co-angle Z*p*☽ :: Tangent *p*Z : Tangent *pd*.
Take *pd* from *p*☽ and the remainder will be ☽*d*; then fay
Sine Co-*pd* : Sine Co-☽*d* :: Sine Co-*p*Z : Sine Co-Z☽.

For angle *p*☽Z, the moon's parallactic angle.

Sine ☽*d* : Sine *pd* :: Tangent angle Z*p*☽ : Tangent angle *p*☽Z.

We muft next find the moon's parallax in altitude, preparatory to which, let the moon's diftance from the earth in femidiameters of the earth be found.

In plate I, figure II, in the plain right-angled triangle B A C, right-angled at B, let C B be the ſemi-diameter of the earth, which call 1, the angle B A C the moon's horizontal parallax, the hypotenuſe C A the moon's diſtance from the earth's center in ſemi-diameters of the earth, to find which ſay Sine angle B A C : ſide B C :: Radius : hypotenuſe C A.

Having found the moon's diſtance from the earth's center, there are given in plate I, figure III, in the plain oblique-angled triangle B A C, the ſide A C = the moon's diſtance from the earth's center, the ſide B C = the earth's ſemi-diameter, and the included angle B C A = the moon's true zenith diſtance, to obtain angle B A C = the difference between angle B C A the true zenith diſtance and D B A the viſible zenith diſtance = the moon's parallax in altitude; to find which, ſubtract angle B C A from 180° the ſum of the three angles, the remainder will be the ſum of the two unknown angles A B C and B A C : Take the ſum and difference of the ſides A C and B C; then ſay, the ſum of the two ſides A C and B C : their difference :: the Tangent of half the ſum of the two unknown angles : the Tangent of half their difference. Subtract the half difference from the half ſum, and the remainder will be the leſſer angle BAC = the moon's parallax in altitude,* which added

* The common method of deducing the moon's parallax in altitude from her true zenith diſtance is by approximation; finding the parallax for the true zenith diſtance as if it were the viſible, by adding together the logarithmic Sine of the zenith diſtance and of the horizontal parallax: then adding the parallax thus found to the true zenith diſtance, and conſidering the ſum as the viſible zenith diſtance, and then going over the work again; but I have exhibited the above method as the direct one; and it is but little longer than the other.

added to the true zenith diſtance, will give the viſible = angle DBA.

For the parallax in latitude and longitude.

Having found the moon's parallax in altitude ſuppoſe it ſet off plate I, figure I, upon the vertical arc from ☽ to m towards the horizon, becauſe the viſible zenith diſtance is greater than the true; then, the point m will be the moon's viſible place, or her place as ſeen from ſome given ſpot on the earth's ſurface. From p to L, through m, let the arc pmL be drawn; then, in the triangle pm☽, the angle mp☽ = the diſtance between n and e on the ecliptic is the moon's parallax in longitude; and the ſegment my, of the ſide pm, is her parallax in latitude; to find which by ſpheric trigonometry, there are given two ſides and the included angle, viz. ſide p☽, the moon's diſtance from the pole of the ecliptic; the ſide ☽m, the moon's parallax in altitude, and angle p☽m = the ſupplement of angle p☽Z to 180°. Or it may be more convenient to take the triangle L☽m; in which are given ſides L☽ and ☽m and the included angle L☽m, = p☽Z to obtain the ſame things. But the moon's parallax in latitude and longitude may be found more eaſily, by the following method.—Let fall the perpendicular mr upon the arc p☽L; then, there will be formed a right-angled triangle ☽mr, right-angled at r. As the perpendicular mr, in eclipſes of the ſun, and even in occultations of fixed ſtars by the moon, will always be near the ecliptic, it may be conſidered as parallal to it, without any ſenſible error; conſequently, the ſide mr may be reckoned = the ſegment ym. We may therefore call the ſide ☽r the moon's parallax in latitude, and the ſide mr, augmented in the ratio of the Sine of the moon's viſible co-latitude to radius,

dius, will be equal to *ne*, the parallax in longitude. In occultations, when the moon's latitude is conſiderable, this augmentation muſt take place; but in ſolar eclipſes, her latitude is always ſo ſmall, that the difference between *mr* and *ne* is imperceptible; therefore, *mr* may be conſidered as the true parallax in longitude..

As the ſides of the triangle ☽ *mr* are very ſhort, it may be reckoned a plain one, without any perceptible error; and the ſides ☽ *r* and *mr* may be found by plain right-angled trigonometry, the hypotenuſe ☽ *m*, and the angle *m*☽ *r* = angle *p*☽ Z, being given.

For ſide ☽ *r*, the moon's parallax in latitude.

Radius : ☽ *m* in ſeconds :: Sine co-angle *m*☽ *r* : ſide ☽ *r* in ſeconds.

For ſide *mr*, the parallax in longitude.

Radius : ☽ *m* in ſeconds :: Sine angle *m*☽ *r* : ſide *mr* in ſeconds.

General rules for applying the Parallaxes.

In a place in north latitude, when the moon's latitude is north, if the parallax in latitude is leſs than the true latitude of the moon, ſubtract it from her latitude; the remainder will be her viſible latitude north. If the parallax be the greater, ſubtract her latitude therefrom; the remainder will be the moon's viſible latitude ſouth. If the true latitude of the moon be ſouth, the parallax in latitude, whether greater or leſs, muſt be added, and the viſible latitude will be ſouth. Theſe rules muſt be inverted, when the latitude of a place is ſouth.

The

The parallax in longitude muſt be added to the moon's true longitude, to give the viſible, when her true longitude is to the eaſt of the nonageſimal degree, otherwiſe, it is to be ſubtracted.

If the moon's true latitude and longitude are to be found from the viſible, the above rules, for applying the parallaxes, muſt be inverted.

For the moon's augmented or viſible ſemi-diameter according to her altitude or zenith diſtance.

The viſible diameter of the moon, to a ſpectator on the ſurface of the earth, is continually enlarging, from the horizon to the zenith ; becauſe the ſemi-diameter of the earth bears a ſenſible proportion to the moon's diſtance. When the moon is in the zenith of an obſerver on the earth's ſurface, ſhe is nearer to him by almoſt a whole ſemi-diameter of the earth, than when ſhe is in his horizon. In the horizon, therefore, the moon's viſible diameter muſt be the leaſt, and in the zenith the greateſt of all.

The viſible diameter of any planet is inverſely as it's diſtance from us ; therefore, to find the moon's augmented ſemi-diameter, from her horizontal, at a particular zenith diſtance, we muſt ſay,—The moon's diſtance from the earth's ſurface at the given viſible zenith diſtance : her horizontal diſtance, or diſtance from the earth's center† :: her horizontal ſemi-diameter : her augmented or viſible ſemi-diameter at the given zenith diſtance. But ſides of plain triangles are meaſured by the ſines of

† The moon's diſtance from a ſpectator at the earth's center is the ſame, at every altitude, as her horizontal diſtance.

of the opposite angles; thus in plate I, figure III, sine angle BCA, the moon's true zenith distance, measures the side AB, the moon's distance from a spectator on the earth's surface; and sine angle A B C, or which is the same, sine angle DBA, the moon's visible zenith distance measures the side A C, the moon's distance from the earth's center = her horizontal distance. We may therefore say, Sine angle A C B, the moon's true zenith distance : sine angle D B A, her visible zenith distance :: her horizontal semi-diameter : her augmented or visible semi-diameter.*

For the visible difference of longitude between the center of the sun and moon.

To obtain this, there are given the sum of the sun's horizontal semi-diameter, and the moon's augmented or visible semi-diameter, at the time of the observed beginning or ending of the eclipse, for which the calculation is made, and the visible latitude of the moon from the sun, found by properly applying the parallax of latitude from the sum, by which a plain right-angled triangle may be formed. Thus in the plain right-angled triangle ☉E☽, plate I, figure IV, there will be given the hypotenuse ☉☽ = the sum of the semi-diameter of the sun or moon,† or visible distance of their center, and the side E☽, the

* The augmentation of the moon's semi-diameter to her altitude or zenith distance may be found in some astronomical tables; but I thought it best to give the trigonometrical process.

† This sum of the semi-diameter ought to be diminished, on account of dissfraction, or the inflection of the rays which pass the limbs of the moon, supposed to be caused by her atmosphere. When an eclipse or occultation would appear to us to be just begun, were there no inflexion, this causes her limb to be visibly distant from

the viſible difference of latitude between their centers, to find the ſide ⊙E, their viſible difference of longitude.* This may be obtained by Euclide, Book I, Prop. 47; or it may be found by common trigonometry thus ⊙☽ : Radius :: E☽ : ſine angle E⊙☽; then Radius : ⊙☽ :: ſine co-angle E⊙☽ = angle E☽⊙ : ⊙E. But ⊙E may be obtained more expeditiouſly, thus; find the logarithms for the ſum and difference of ⊙☽ and E☽; the half ſum of theſe logarithms is the logarithm of ⊙E.

Having found, for the place from whence we deſign to reckon the difference of meridians, the parallaxes, and the viſible difference of longitude between the centers of the ſun and moon, at the obſerved time of the beginning or ending of a ſolar eclipſe, or occultation of a fixed ſtar, or for both the beginning and ending, where both have been obſerved, we muſt aſſume the difference of meridians in time, between the firſt

C place,

from the limb of the ſun, or from the fixed ſtar $4\frac{1}{2}''$: Therefore, at the inſtant when the beginning or end appears to us, it is obvious, that the centers cannot be ſo far aſunder by $4\frac{1}{2}''$, as the ſum of the ſemi-diameters; and by ſo much muſt this ſum be diminiſhed. For a brief account of this inflection, ſee ASTRONOMIE par M. DE LA LANDE, tome ii. art. 1992, 1993, edition ſeconde.

* As the ſun has a viſible latitude, equal to his parallax in latitude, the ſide ⊙E is not a portion of the ecliptic, but is parallel to it: But as it's utmoſt diſtance from it can never be more than between 8″ and 9″, the difference between this ſide and the viſible difference of longitude, is imperceptible. In an occultation, when the ſtar's latitude is large, this ſide, parallel to the ecliptic, muſt be enlarged, to give the viſible difference of longitude between the ſtar and the moon's center, in the ratio of the coſine of the moon's viſible latitude, or of the ſtar's latitude to Radius, according as the one or the other is neareſt to the ecliptic.

place, and that whoſe longitude is ſought; and muſt find the parallaxes the augmented ſemi-diameter of the moon and the difference of longitude between the centers of the ſun and moon, or ſtar and moon, for the obſerved time of the beginning or ending of the eclipſe, or occultation, at this ſecond place.

We are next to find the time of the true ecliptic conjunction of the moon and ſun, or moon and ſtar, according to obſervation: And here we are to obſerve, that at the beginning of an eclipſe or occultation, the moon is viſibly not ſo far advanced in longitude, as the ſun or ſtar, therefore, if we ſubtract the viſible difference of longitude from the ſun's viſible longitude,* or from the ſtar's true longitude,† we ſhall have the viſible longitude of the moon. If to this viſible longitude, we apply her parallax in longitude, with it's proper ſign, we ſhall have her true longitude according to obſervation, the ſun's or ſtar's longitude being ſuppoſed to be accurately given by the tables. If we make uſe of the moon's parallax in longitude from the ſun inſtead of her ſimple parallax, which will prevent a ſeparate calculation for the ſun's parallax in longitude, the viſible difference of longitude being ſubtracted from, or added to the ſun's true longitude will give the moon's viſible longitude nearly; and her parallax in longitude from the ſun properly applied to this will give her true longitude.

The

* The ſun's viſible longitude is found by applying his parallax in longitude with the proper ſign to his true longitude.

† As the fixed ſtars have no perceptible parallax, there can be no diſtinction in calculations between the viſible and true longitude.

The difference between the ſun's or ſtar's longitude and the moon's thus found will, it is obvious, be the true difference of longitude between them. But this may be found more readily thus—In eclipſes, if the viſible difference of longitude and the moon's parallax in longitude from the ſun, and in occultations, the moon's ſimple parallax, be both additive or both ſubtractive, their ſum is the true difference of longitude, between the moon and ſun or ſtar. If the one is additive, and the other ſubtractive, their difference is the difference of longitude.

It ſometimes, though rarely, happens, that the moon, at the beginning of an eclipſe or occultation, has paſt the true conjunction,* although her viſible longitude is leſs ; this is the caſe when the parallax, being additive, is greater than the difference of longitude between the moon and ſun or ſtar. We muſt invert this rule, to know whether the moon has paſt the true conjunction, at the end.

The true difference of longitude between the moon and ſun, or moon and ſtar being found, both for the beginning and ending of a ſolar eclipſe, or of an occultation, where both have been determined by obſervation, the ſum of theſe, when the moon was on different ſides of the point of the true ecliptic conjunction, at the beginning and ending or the difference, when ſhe was upon the ſame ſide in both, will be her whole motion in longitude from the ſun or ſtar during the time of the

 eclipſe

* We ſhall find an inſtance of this at the beginning of the ſolar eclipſe at Greenwich, June 24, 1778.

eclipse or occultation, according to observation.* Then we must say, This whole motion : the whole time of the duration :: the difference of longitude at the beginning or ending : the distance in time between the observed beginning or ending and the true ecliptic conjunction.

When the beginning or ending only has been observed, at the places for which we made the calculations, we must use the moon's horary motion from the sun, as given by the tables, for the first term, and one hour or 3600″, for the second term.

The time thus found is to be added to the observed time of the beginning of the eclipse or occultation, when the moon is behind the true conjunction ; but if she has passed it, then it must be subtracted ; and the sum or difference will be the time of the true ecliptic conjunction according to observation.

This

* If this whole motion is considerably different from that given by the tables, and we make dependance upon the observations of the beginning and end of the eclipse or occultation, we are to conclude, that the moon's latitude, by the tables, is not exact ; and the correct latitude must be sought, for the beginning and end. These being obtained, the visible difference of longitude between the sun's and moon's center is to be found, conformably thereto. By this it is supposed, that the moon's horary motion, by the tables, is true ; which may be concluded to be generally the case, in eclipses and occultations ; and indeed it is much more likely that the latitude should be given too small or too large, in the tables, than that the horary motion should be considerably erroneous by them. In more than five hundred longitudes of the moon, calculated from Mayer's printed tables, by M. Lemery, which he compared with corresponding longitudes, deduced from the lunar observations of the late accurate and celebrated Dr. Bradley ; which comparisons are published in *Connoisance des Temps pour l' Année*, 1783, I find that the error in the moon's horary motion in longitude rarely amounts to 2″. It is not common for it to exceed 1″ ; and it is generally but a few tenths of a second. We may therefore make great dependance upon the horary motion given by these tables.

This rule is to be inverted, to find the time of conjunction from the observation of the end of the eclipse or occultation.

The time of the true ecliptic conjunction, according to the observations, being found in this manner, for each place, the difference of times will be the difference of meridians.

Let the preceding rules be now exemplified.

The beginning of a solar eclipse was observed at the Royal Observatory at Greenwich, by Dr. Maskelyne, the Astronomer Royal, August 5, 1766, at $5^{h.}\ 29'\ 56''$ P. M. apparent time, and by his assistant at $5^{h.}\ 29'\ 58''$ P. M. the mean being $5^{h.}\ 29'\ 57''$. The end was observed by the Doctor at $7^{h.}\ 11'\ 27''$, and by his assistant at $7^{h.}\ 11'\ 40''$ P. M. the mean being $7^{h.}\ 11'\ 33''\frac{1}{2}$.

The same eclipse was observed by the late Dr. Winthorp, Hollis Professor of the Mathematics and Natural Philosophy, at Cambridge, who made the beginning at $11^{h.}\ 39'\ 23''$ A. M. and the end at $2^{h.}\ 45'\ 9''$ P. M. apparent time.

Required the difference of meridians between Greenwich and Cambridge, by these corresponding observations?

The solar and lunar elements for calculating the parallaxes, &c. are from Mayer's tables.

For Greenwich at $5^{h.}\ 29'\ 57''$.

The sun's longitude,	$4^{s.}$	13°	$9'$	$51''$	o
The moon's ecliptic longitude,	4	13	3	59	o

The

The moon's latitude north decreasing,	°	33′	17″	0
The sun's horary motion,		2	43	2
The moon's horary motion in longitude in the ecliptic,		29	29	5
The moon's horary motion in latitude,		2	43	2
The moon's horizontal parallax for Greenwich,		53	58	4
The sun's horizontal parallax,			8	4
The moon's horizontal parallax from the sun,		53	50	0
The sun's horizontal semi-diameter by observation,		15	47	0
The moon's horizontal semi-diameter,		14	44	5
The obliquity of the ecliptic,	23	28	18	0
The latitude of Greenwich Observatory,	51	28	39	
Reduced to the center,	51	14	11	
Complement = PZ	38	45	49	

From these elements the altitude of the nonagesimal degree

has already been found,	s.	29°	38′	12″
And it's longitude,	6	5	6	11
From which subtract the moon's longitude,	4	13	3	59
The difference is equal to angle Zp ☽,	1	22	2	12
		= 52	2	12

For the moon's zenith distance and parallactic angle. Plate I.

Figure I.

For side Z ☽.

Radius,						
: Sine Co-angle	Zp☽	37	57	48	9	7889864
:: Tangent	pZ	29	38	12	9	7550557
: Tangent	pd	19	17	20	9	5440421
	p☽	89	26	43		
	☽d	70	9	23		Sine

	Sine Co	*pd*	70	42	40	9	9749099
:	Sine Co	☽*d*	19	50	37	9	5307810
::	Sine Co	*pZ*	60	21	48	9	9391086
:	Sine Co	Z☽	18	12	56	9	4949797
			90				
	☽'s zen. dist.	= Z☽	71	47	4		

For angle *p*☽Z.

	Sine	☽*d*	70	9	23	9	9734755
:	Sine	*pd*	19	17	20	9	5189498
::	Tangent angle	Z*p*☽	52	2	12	10	1077631
:	Tangent angle	*p*☽Z	24	13	55	9	6532974

= *m*☾*r* the parallactic angle.

For the moon's distance from the earth in semi-diameters of the earth. Plate I. Fig. II.

	Sine angle BAC = the moon's horizontal parallax from sun,	0° 53′ 50″	8	1947596
::	BC, the earth's semi-diameter,	1		
::	Radius		10	
:	AC, the moon's distance from the earth's center,	63 8617*	1	8052404

For

* This is not strictly the moon's distance from the earth, because her horizontal parallax from the sun is here used, instead of her true parallax; but the number thus found is to be taken for the next process, because, in these calculations, we find her parallax in altitude, latitude and longitude from the sun, to prevent separate processes for his parallaxes. When we are making these calculations in occultations of the fixed stars by the moon, her true horizontal parallax will necessarily be used, because the fixed stars have no discoverable parallax.

For the moon's parallax in altitude. Plate I, Fig. III.

Sum of the three angles,	180° 0′ 0″
Angle BCA = ☽'s zenith diſtance,	71 47 4
Sum of the two unknown ∠'s	180 12 56
Half ſum	54 6 28
Side CA = ☽'s diſtance from the earth's center,	63 8617
Side BC = earth's ſemi-diameter,	1
Sum of the two ſides including the known angle,	64 8617
Their difference,	62 8617

The ſum of the two ſides including the known angle,	64 8617	1 8119883
: Their difference,	62 8617	1 7983861
∴ Tangent ½ ſum of the two unknown angles,	54° 6′ 28″	10 1404579
: Tangent ½ their difference,	53 15 5	10 1268557
Leſſer angle BAC or ☽'s parallax in altitude from ſun,	51 23	
	60	
	3083	

The finding of the moon's parallax in altitude, from her true zenith diſtance, may be much facilitated by the following ſhort table, which I have calculated for the purpoſe.

TABLE.

TABLE.

☽'s horiz. par^x.	Logarithms.	Difference.
53′	0 0133919	2526
54	0 0136445	2526
55	0 0138971	2526
56	0 0141497	2527
57	0 0144024	2527
58	0 0146551	2527
59	0 0149078	2528
60	0 0151606	2528
61	0 0154134	2528
62	0 0156662	

The first column of this table contains the moon's horizontal parallaxes in minutes. In the second column are the logarithms, which are to be subtracted from the logarithmic tangent of the half sum of the two unknown angles (found as above) according to the moon's horizontal parallax. The remainder will be the logarithmic tangent of the half difference of those angles. The degrees, &c. answering to this, being subtracted from the half sum, will give the parallax in altitude.

The use of the table exemplified.

Required the moon's parallax in altitude from the sun, her horizontal parallax from the sun being 53′ 50″, and her true zenith distance 71° 47′ 4″, as before?

The Tang. $\frac{1}{2}$ sum of the two unknown angles, as above,	54° 6′ 28″	10 1404579
Logarithm from the table for	53 50	0 0136024
The Tang. $\frac{1}{2}$ difference of the two unknown angles,	53 15 5	9 1268555
The moon's parallax in altitude from the sun, as before,	51 23	

For the moon's parallax in altitude from the sun by approximation.

Sine of the moon's true zenith distance,	71° 47′ 4″		9 9776721
The moon's horiz. par. from the sun,		3230*	3 5092025
Moon's par. in altitude from sun nearly		3068	3 4868746
	= 51′ 8″		
	71 47 4		
The moon's visible zen. dist. nearly	72 38 12	Sine	9 9797448
		3230″ Log.	3 5092025
The moon's par. in alt. from the sun,		3082, 8	3 4889473

This is but $\frac{2}{10}$ of a second different from the parallax which was found by the direct method.

For the moon's parallax from the sun in longitude and latitude.
Plate I, Figure I.

Radius			
: ☽m the moon's parallax in altitude from the sun,	3083″	3	4889735
:: Sine angle p☽Z = m☽r the parallactic angle,	24° 13′ 55″	9	6132407
: mr the moon's parallax in longitude from the sun,	1265, 3	3	1022142
	= 21′ 5″, 3		

Radius			
: ☽m	3083″	3	4889735
			:: Sine

* The arc of this parallax is so small, that we may use the logarithm of the seconds contained in it, instead of the sine of the arc without any sensible error.

:: Sine co-angle $p☽Z$	65° 46′ 5″	9 9599432
: ☽r the moon's paral. in lat. from sun, 2811, 3		
	= 46′ 51″, 3	3 4489167

For the moon's visible or augmented semi-diameter.

The Sine of the moon's true zen. dist.	71 47 4	9 9776721
: The Sine of her visible zen. dist.	72 38 27	9 9797546
:: Her horiz. semi-diameter, 14′ 44″, 5 =	884″, 5	2 9466978
: Her augmented semi-diameter,	888, 8	
		2 9487803

Such is the trigonometrical process, for finding the moon's parallax in latitude and longitude, and her augmented or visible semi-diameter; but astronomers have invented *formulas*, which greatly shorten the work, making it unnecessary to find the moon's zenith distance, parallactic angle, and parallax in altitude. In solar eclipses, the moon's latitude being very small, the *formulas* are quite concise and easy.

Let the parallax in latitude be called x, and in longitude y. Let the co-sine of the altitude of the nonagesimal degree be called C and it's sine D. Let the moon's horizontal parallax or her horizontal parallax from the sun be called p, her *visible* latitude l, and *true* latitude L. Let the distance between the moon's *visible* longitude and the longitude of the nonagesimal degre = Zpm in Plate I, Fig. I, be called b; the *true* = Zp☽, B. Then, the *visible* latitude and longitude of the moon being given,

$x = p\text{C} \mp p\text{D}$ sine l co-sine b,

$y = p\text{D}$ sine b.

 The

The ſubtractive ſign — is to be uſed, when the moon's latitude is north, the additive + when it is ſouth.

In occultations, when the moon's latitude is large,
$x = p$C co-ſine $l \mp p$D ſine l co-ſine b.

$y = \dfrac{p\text{D ſine } b}{\text{Co-ſine L}}$ } i. e. y, found by pD ſine b, muſt be enlarged in ratio of the co-ſine of the moon's true latitude to Radius.

Formulas have been invented to find the parallaxes in a direct way, when the moon's *true* latitude and longitude are given; but it is rather eaſier, in this caſe, to come at them by approximation, thus,

Add together logarithm p, ſine D, ſine B, which will give y, or the parallax in longitude nearly. Add the parallax thus found to B, which will give b nearly, viz. the diſtance between the moon's *viſible* longitude and the longitude of the nonageſimal degree. Then log. p, ſine D, ſine b thus nearly found, will give y, the parallax in longitude, ſufficiently exact; and this added to B will give correct b. Add together log. p, ſine C, which will give x, or the parallax in latitude nigh the truth. This being properly applied to L, the moon's *true* latitude, will make l, the *viſible* latitude, nearly. Then add together log. p, ſine D, ſine l, thus nearly found, and co-ſine b, which give the logarithm of a number, that added to, or ſubtracted from x, as before nearly found, will make the correct parallax in latitude.

With reſpect to the moon's augmented ſemi-diameter we may ſay B : C :: the moon's horizontal ſemi-diameter : her augmented

mented femi-diameter. Her augmented femi-diameter, thus found, will be fufficiently correct for all purpofes.

Exemplification.

The co-altitude of the nonagefimal degree,	60° 21′ 48″	Sine	9 9391086	C
The altitude of the nonagefimal degree,	29 38 12	Sine	9 6941647	D
The moon's horiz. par. from the fun,	53′ 50″ = 3230″	Log.	3 5092025	p
The dift. between the moon's true long. and the long. of the nonagefimal degree,	52 2 12	Sine	9 8967492	B
The moon's true latitude,	33 17 N = L			

p	3	5092025
D	9	6941970
B	9	8967492
y nearly 1259″	3	1001487
= 20′ 59		
B 52 2 12		
b nearly 52 23 11 Sine	9	8988045
pD	3	2033995
1265″,3	3	1022040

= 21′ 5″,3 ☽'s parallax in long. from ☉

B 52 2 12

b correct 52 23 17 Sine 9 8988143

	p	3 5092025	
	C	9 9390986	
x nearly 2807″, 4		3 4483011	
= 46′ 47″	S		
☽'s true lat. = L 33 17	N		
l nearly, viz. ☽'s vis. lat. 13 30	S Sine	7 5940588	
	pD	3 2033995	
	Co-sine b	9 7855507	
3″, 8		0 5830090	
x nearly 46′ 47, 4			
+ 3, 8			
x correct 46 51, 2	☽'s parallax in lat. from ☉		

Sine B		52° 2′ 12″	9 8967492
: Sine b		52 23 17	9 8988143
:: The moon's horiz. semi-diameter,	14′ 44″, 5	= 884″, 5	2 9466978
: Her augmented or visible semi-diameter,		888, 8	2 9487629
		= 14′ 48″, 8	

By these results it appears that the foregoing *formulas* find the parallaxes and augmented semi-diameter of the moon to great exactness.

Let us now find the visible difference of longitude between the center of the sun and moon, at Greenwich, at $5^{h.}$ 29′ 57″, when the eclipse begun there. Plate I, Fig. IV.

The

The ☉'s horizontal semi-diameter,			15′ 47″, 0
The ☽'s augmented semi-diameter,			14 48, 8
Sum,			30 35, 8
Subtract for inflection,			4, 5
Visible distance of centers,			30 31, 3
			60
Hypotenuse ☉☽			1831, 3
The ☽'s parallax in latitude from ☉,			46′ 51″, 2 S
The moon's latitude,			33 17, 0 N
The ☽'s visible latitude from ☉,			13 34, 2 S
			60
Side E☽			814, 2
Hypotenuse ☉☽		1831, 3	
Side E☽ ±		814, 2	
Sum,		2645, 5	3 4225078
Difference,		1017, 1	3 0073637
		2	6 4298715
Side ☉E = the visible diff. long. of ☉'s and ☽'s center,		1640, 3	3 2149357
		= 27 20, 3	

For the moon's true longitude according to observation.

From the sun's true long. aug. 5D. 5h. 29′ 57″	4s. 13° 9′ 51″, 0
Subtract ☉'s and ☽'s visible diff. long. by observation,	27 20, 3

Remains

Remains the ☽'s visible longitude nearly,	4	12	42	30, 7	
Add the moon's parallax in longitude from the ☉.		+	21	5, 3	
The sum is the ☽'s true long. according to observ.	4	13	3	36, 0	
The true diff. of long. of ☉ and ☽ according to observa.			6	15	
			60		
			375		

Let us now find the requisites for $7^{h.}$ $11'$ $33\frac{1}{2}''$ when the eclipse ended at Greenwich.

Elements for computing the parallaxes, &c. at $7^{h.}$ $11'$ $33\frac{1}{2}''$

The sun's longitude,	$4^{s.}$	13°	13'	54", 5	
The moon's ecliptic longitude,	4	13	53	55, 6	
The moon's latitude north,			28	40, 6	
The sun's right ascension,		135	42	33	
The right ascension of the mid-heaven,		243	35	55	
Angle *p*PZ,		26	24	5	
Complement,		63	35	55	

Side PZ as before, as also the ☽'s horizontal parallax.*

From these elements are found

The altitude of the nonagesimal degree,		20°	11'	5"
Angle P*p*Z,		126	12	38
The longitude of the nonagesimal degree,	$7^{s.}$	6	12	38

Angle

* As the moon was near her apogee, the horizontal parallax altered so very little, in a few hours, that the same may here be taken for the end, as for the beginning. If the moon is not near her apogee or perigee, at the time of a solar eclipse, allowance should be made for the alteration of the horizontal parallax, between the beginning and end.

Angle Zp☽ = B,	82° 18′ 42″	
The moon's parallax in longitude from the sun,	18 25, 3	
The moon's parallax in latitude from the sun,	50 32, 5	S
The moon's augmented semi-diameter,	14 45, 1	
The sum of the ☉'s and ☽'s semi-diameters—4″,5 for inflection = ☉☽	1827,6″	
The moon's visible latitude from the ☉ = E☽	1311, 9	S
The visible diff. of long. of the ☉'s & ☽'s centers = ☉E	1272, 4	
	= 21′ 12″, 4	

To the sun's true longitude at $7^{h.}$ 11′ 33″½	$4^{s.}$	13°	13′	54″, 5	
Add the visible diff. of long. of ☉ and ☽ by observ.		+	21	12, 4	
The sum is the ☽'s visible longitude nearly,	4	13	35	6, 9	
Add the ☽'s parallax in long. from the sun,		+	18	25, 3	
The sum is the ☽'s true long. according to obs.	4	13	53	32, 2	
The true diff. of long. of ☉ and ☽ at the end by obs.			39	37, 7	
			60		
			= 2377, 7		
The true diff. by observation at the beginning,			+ 375, 0		
The whole motion of the ☽ from the ☉ in the ecliptic by observation,			2752, 7		

By Mayer's tables

The moon's long. at the beginning of the eclipse,	$4^{s.}$	13°	3′	59″, 0	
Ditto at the end,	4	13	53	55, 6	
The difference = the moon's whole motion during the eclipse,			49	56, 6	

The sun's motion for the same time, —4′ 3,″ 5

The whole motion of the ☽ from the ☉ by Mayer's tables 45 53, 1
60

2753, 1

By this it appears, that the whole motion of the moon from the sun in the ecliptic, by observation, differs but 0″, 4 from that given by the tables: Therefore, if we suppose the horary motions by these to be correct, the latitude will be nearly exact, the observations being allowed good.

For the time of the true conjunction of the sun and moon according to observation.

The beginning of the eclipse by obs. at Greenwich,	$5^{h.}$ 29′ 57″
The end,	7 11 33½
The difference = the duration	1 41 36½
	60
	101
	60
	6096½

The whole motion of ☽ from the ☉ during the eclipse,	2752″, 7	3 4397589
: The time of the duration,	6096½,	3 7850806
:: Diff. long. ☽ & ☉ at the beginning by obs.	375, 0	2 5740313
: The time from the begin. to ecliptic conju.	830½	2 9193530
	= 13′ 50″½	

To

To the time of the beginning of the eclipse by observ.	$5^{h.} 29' 57''$
Add	$13\ 50\frac{1}{2}$
The sum is the time of ecliptic conjunction by observ.	$5\ 43\ 47\frac{1}{2}$

SCHOLIUM.

From the observation of the beginning or ending of a solar eclipse, at a place, for which astronomic tables have been constructed, or, at a place, whose difference of longitude from that, for which the tables have been constructed, is accurately ascertained, the error in the moon's longitude as given by them, may be known, if they have given her latitude exact, or the error, if there be one, has been corrected by observation. For example, when the foregoing eclipse began at Greenwich, the moon's longitude, by Mayer's printed tables, was $4^{s.} 13° 3' 59'', 0$, but, deduced from the observations, it was but $4^{s.} 13° 3' 36'', 0$; the error of these tables, therefore, in the moon's longitude, at that time, was $+ 23''$, supposing the latitude exact. By the observation of the end the error was $23'', 4$.

Having found the time of the ecliptic conjunction of the sun and moon, at Greenwich, as deduced from the observations of the beginning and ending of the eclipse, we are next to find the conjunction at Cambridge, from the observations made there.

Let us assume the difference of meridians between Greenwich and Cambridge to be $4^{h.} 44' 25''$, then, at $11^{h.} 39' 23''$, A. M. when the eclipse began at Cambridge, it was $4^{h.} 23' 48''$, P. M. at Greenwich; and the sun's longitude and right ascension, and the moon's latitude and longitude were the same, at each place.

Having found these for Greenwich, at $5^{h.}$ 29′ 57″, P. M. it will be easy to obtain them for $4^{h.}$ 23′ 48″, answering to $11^{h.}$ 39′ 23″ at Cambridge, by the solar and lunar motions for $1^{h.}$ 6′ 9″, the difference between $5^{h.}$ 29′ 57″ and $4^{h.}$ 23′ 48″.

Elements for Cambridge at $11^{h.}$ 39′ 23, A. M.

The sun's longitude,	$4^{s.}$	13°	7′	12″,5
The moon's ecliptic longitude,	4	12	31	28, 1
The moon's latitude north,			36	16, 8
The moon's horizontal parallax,			54	0, 5
The sun's right ascension,		135	35	35
The right ascension of the mid-heaven,		130	26	20
Angle pPZ		139	33	40
	=	40	26	20
Complement		49	33	20
The latitude of Cambridge,		42	23	28 N
Reduced to the center,		42	8	37
Complement = PZ		47	51	23

From these elements are found,

The altitude of the nonagesimal degree,		67	0	6
Angle PpZ		31	30	11
The longitude of the nonagesimal degree,	4	1	30	11
Angle Zp☽ = B		11	1	17
The moon's parallax in longitude from the sun,			9	36,8
The moon's parallax in latitude from the sun,			20	49,9 S
The moon's augmented semi-diameter,			14	57,2
The sum of the ☉'s and ☽'s semi-diameter—4″,5 for inflection = ☉☽,			18	39,7
The moon's visible latitude from the sun = E☽,			9	26,9 N

The

The visible diff. of long. of the ☉'s & ☽'s centers = ☉E 1589'',1
= 26' 29'',1

From the sun's true longitude at Cambridge, at $11^{h.}\ 39'\ 23''$,	$4^{s.}\ 13°\ 7\ 12,\ 5$
Subtract ☉'s and ☽'s visible diff. long. by observation,	— 26 29, 1
	4 12 40 43, 4
Subtract the moon's parallax of longitude from ☉,	—9 36, 8
The moon's true long. according to observa.	4 12 31 6, 6
The true diff. of long. of ☉ & ☽ according to observa.	36 5, 9
	60
	2165, 9

Elements for the end of the eclipse at Cambridge, at $2^{h.}\ 45'\ 9''$, P. M.

The sun's longitude,	$4^{s.}\ 13°\ 14'\ 37'',7$
The moon's ecliptic longitude,	4 14 2 46, 7
The moon's latitude north,	27 51, 5
The sun's right ascension,	135 43 1
The right ascension of the mid-heaven,	177 0 16
Angle pPZ	92 59 44
	= 87 0 16
	Complement

From these elements are found,

The altitude of the nonagesimal degree,	53 7 38
Angle PpZ,	67 45 32
The longitude of the nonagesimal degree,	5 7 45 32

Angle

Angle Z*p* ☽ = B,	23° 42′ 45″
The moon's parallax in longitude from the sun,	17 31, 7
The moon's parallax in latitude from the sun,	32 22, 5
The moon's augmented semi-diameter,	14 54, 7
The sum of the ☉'s and ☽'s semi-diameters — 4″,5 for inflection = ☉ ☽,	1837, 2
The moon's visible latitude from the ☉ = E ☽,	271, 8
The visible diff. of long. of ☉'s and ☽'s centers = ☉E	1817, 1
	= 30 17, 1
To the sun's true longitude at Cambridge, at 2^h. 45′ 9″,	4^s. 13 14 37, 7
Add ☉'s and ☽'s visible diff. long. by observation,	+ 30 17, 1
	4 13 44 54, 8
Add the moon's parallax of longitude from ☉,	+ 17 31, 7
The true long. of the moon according to obs.	4 14 2 26, 5
The true diff. of long. of ☉ and ☽ according to observa.	47 48, 8
	60
	2868, 8
The true difference by observation at the beginning 11^h. 39′ 23″, A. M.	2165, 9
The whole motion of ☽ from ☉ in the ecliptic by obs.	5034, 7

By Mayer's tables,

The moon's long. at the beginning of the eclipse,	4^s. 12° 31′ 28″,1
Ditto at the end,	4 14 2 46, 7
Diff. = ☽'s whole motion in the ecliptic during the eclipse,	1 31 18, 6

The

The sun's motion for the same time, 7′ 25″,2

The whole motion of ☽ from ⊙ by Mayer's tables, 1 23 53, 4

60

83

60

5033, 4

By this it appears that the whole motion by observation differs but 1″,3 from that given by Mayer's tables.

The time of the duration of the eclipse by observation was 11146″.

For the time of the true conjunction of the sun and moon at Cambridge by observation.

The whole motion of ☽ from ⊙ in the ecliptic during the eclipse,	5034″,7	3	7019736
: The time of the duration,	11146	4	0471190
:: Diff. long. ☽ and ⊙ at the begin. by observ.	2165, 9	3	3356384
: The time from the beginning to the ecliptic ☌ by observation,	4795	3	6807838

= 79′ 55″.

Add this time,	= 1h.	19	55
To the time of the beginning by observa.	11	39	23
The sum is the time of ecliptic ☌ by observa.	0	59	18
Time of ecliptic ☌ at Greenwich by observa.	5	43	47½
Diff. = the diff. of meridians between Greenwich & Cambridge by observa.	4	44	29½

Thus

Thus it appears, that according to the observations of this eclipse made at Greenwich and Cambridge, the difference of meridians between those places is $4^{h.}\ 44'\ 29\frac{1}{2}''$; so that the time that was assumed for the difference was very near the truth. If the difference of meridians, thus deduced, is in any case considerably different from that which was assumed, this result is to be considered as only the approximate difference, and is to be used as a new-assumed difference, from which deductions are to be made for the true. If the first result does not differ more than two or three minutes from the assumed difference of meridians, the same parallax in longitude and latitude may be used in the second process, which were found and used in the first; because the right ascension of the mid-heaven will not differ more than $6''$ or $8''$ from the first = the difference in the sun's right ascension, which, together with the small difference in the moon's longitude and latitude, will make so trifling a difference in her zenith distance and parallactic angle, that the difference of parallaxes will be inconsiderable. All, therefore, that is necessary to be done, in the second process, is to find the sun's longitude and the moon's latitude for the approximate or new assumed difference of meridians, from whence, with the parallaxes, we must deduce the difference of longitude between the sun and moon, whereby the true conjunction will be obtained.

For illustration, let us take the foregoing observations of the solar eclipse, and assume $4^{h.}\ 42\ 25$ for the difference of meridians between Greenwich and Cambridge.

According to this assumption, at $11^{h.}\ 39'\ 23''$, A. M. when the eclipse began at Cambridge,

The

The sun's longitude by the tables,	$4^{S.}$	13°	$7'$	$7'',7$
The moon's ecliptic longitude,	4	12	30	29, 1
The moon's latitude,			36	22, 2
The sun's right ascension,		135	35	30
The right ascension of the mid-heaven,		130	26	15
Angle pPZ		139	33	45
=		40	26	15
Complement		49	33	45

Hence

The altitude of the nonagesimal degree,		67	0	7
Angle PpZ,		31	29	49
The longitude of the nonagesimal degree,	4	1	29	49
Angle Zp☽ = B,		11	0	40
The moon's parallax in longitude from the sun,			9	36, 3
The moon's parallax in latitude from the sun,			20	49, 8 S
⊙ ☽ as before,				1839″,7
E☽ or the moon's visible latitude from the sun,				932, 4
The visible diff. of long. of ⊙'s and ☽'s centers = ⊙E				1585, 9
				= 26′25″,9
The ☽'s ecliptic long. by observa. according to the above assumption,	4^{S}	12°	31	5, 5
The true diff. of long. of ⊙ and ☽ by observation according to the assumption,			36	2, 2
				60
				2162, 2

At the end of the eclipse at Cambridge at $2^{h.}\,45'\,9''$ according to the above assumption,

F The

The sun's longitude,	4s. 13°	14′	32″,9	
The moon's ecliptic longitude,	4 14	1	47, 7	
The moon's latitude,		27	56, 9	
The sun's right ascension,	135	42	56	
The right ascension of the mid-heaven	177	0	11	
Angle pPZ,	92	59	49	
	= 87	0	11	
Complement	2	59	49	

Hence

The altitude of the nonagesimal degree,	53	7	40	
Angle PpZ	67	45	30	
The longitude of the nonagesimal degree,	5 7	45	30	
Angle $Zp☽ = B$	23	43	42	
The moon's parallax in longitude from the sun,		17	31, 7	
The moon's parallax in latitude from the sun,		32	22, 4	
⊙☽ as before,			1837″,2	
E☽			265, 5	
The visible diff. of long. of ⊙'s and ☽'s centers = ⊙E			1817, 9	
		= 30′	17″,9	
The moon's ecliptic long. by observation according to the above assumption,	4 14	2	22, 5	
The true diff. of long. of ⊙ and ☽ by observa. at the end of the eclipse, according to the above assumption,		47	49, 6	
			60	
			2869, 6	
The difference at the beginning as above,			2162, 2	
The whole motion of ☽ from ⊙ accord. to this assum.			5031, 8	
			5031″,	

5031″, 8 : 11146″ :: 2162″, 2 : 4789½″ = $1^{h.}$ 19′ 49½″

The beginning of the eclipse at Cambridge,	11	39	23
The ecliptic ☌ of ☉ and ☽ by observa. according to the foregoing assumption,	0	59	12½
Time of ☌ at Greenwich by observation,	5	43	47½
The difference of meridians by this assumption,	4	44	35

By this it appears, that the assumed difference of meridians, viz. $4^{h.}$ 42′ 25″, differs much from the truth : But the parallaxes resulting from this assumption, are so very near those resulting from the first, that it is evident they may be employed in the remaining part of the process, without causing any sensible error. Let $4^{h.}$ 44′ 35″, the difference of meridians now found, be used as a new-assumed difference, which will give the moon's latitude at the beginning of the eclipse at Cambridge 36′ 16″, 5, and at the end 27′ 51″, 2, and by a proper process we shall find the visible difference of longitude of ☉ and ☽ at the beginning 1589″, 3, and the true difference 2165″, 6 ; and at the end the visible difference 1817,″ 1, and the true 2868″, 8. Hence we find the time of ecliptic conjunction at Cambridge $0^{h.}$ 59′ 17½″, and the difference of meridians between Cambridge and Greenwich $4^{h.}$ 44′ 30″, but half a second different from what it was at first found.

If instead of finding the difference of meridians at once, by the conjunction at each place, any one chuses to find it by the beginning and end separately, he may easily do it.

At the beginning of the foregoing eclipse at Greenwich, it appears, that the moon's ecliptic longitude by observation was $4^{s.}\ 13^{\circ}\ 3'\ 36'', 0$, but when it began at Cambridge, her longitude by observation was but $4^{s.}\ 12^{\circ}\ 31'\ 6''$. The difference is $32'\ 29'', 4 = 1949'', 4$. Let us find how long the moon was in passing over this portion of the ecliptic, thus,

The ☽'s horary mot. in long. $29'\ 29'', 5 =$	$1769'', 5$	3 2478506
: 1 hour,	3600	3 5563025
::	1949, 4	3 2899010
:	3966	3 5983529
	$= 1^{h.}\ 6'\ 6''$	

By this it appears, that it was $1^{h.}\ 6'\ 6''$ after the eclipse began at Cambridge, before the moon had the same longitude, as when the beginning was observed at Greenwich : Therefore, to $11^{h.}\ 39'\ 23''$, A. M. add $1^{h.}\ 6'\ 6''$; the sum $0^{h.}\ 45'\ 29''$, shews the time at Cambridge, when she had the same longitude as at Greenwich at $5^{h.}\ 29'\ 57''$; and the difference $4^{h.}\ 44'\ 28''$ is the difference of meridians in time, between those two places as deduced from the observations of the beginning of this eclipse. By a similar process, we find the difference resulting from the observations of the end to be $4^{h.}\ 44'\ 31\frac{1}{2}''$. The mean is $4^{h.}\ 44'\ 29\frac{1}{2}''$.

Another solar eclipse, the observations of which we make use of, to determine the difference of meridians between Greenwich and Cambridge, is that of June 24, 1778. As the clouds were troublesome, at that time, at Cambridge, and consequent-

ly

ly the obſervations ſomewhat uncertain, we may take the obſervation of the end of the eclipſe made at Chelſea, by the Rev. Mr. Payſon, who had a very favourable time. And as Mr. Payſon and I have, by terreſtrial meaſurement, made with much preciſion, found Chelſea to be 26'' in time eaſt of Cambridge, this obſervation is the ſame to our purpoſe, as if made in Cambridge.

The beginning of this eclipſe was obſerved by the Rev. Dr. Nevil Maſkelyne, at the Royal Obſervatory at Greenwich, at $3^{h.}\ 40'\ 11''$, and the end at $5^{h.}\ 25'\ 12''$ apparent time.* At Chelſea, the end was obſerved by the Rev. Phillips Payſon, at his own houſe, at $11^{h.}\ 38'\ 23''$, A. M. apparent time.

At the Royal Obſervatory at Greenwich, at $3^{h.}\ 40'\ 11''$ apparent time.

The ſun's longitude by Mayer's tables,	$3^{S.}\ 3^{\circ}\ 4'\ 2'',0$
The moon's ecliptic longitude,	$3\ \ 3\ \ 6\ \ 32,\ 0$

The

* I am indebted to Mr. De La Lande, a celebrated member of the Royal Academy of Sciences at Paris, for the European obſervations of this eclipſe; who, in a very obliging manner, in a letter of November 30, 1781, communicated them to me. They are as follow:

	At Oxford,	Greenwich,	Deptford,	Stockholm,	Paris,
Beg.	$3^{h.}\ 33'\ 44''$	$3^{h.}\ 40'\ 11''$	$3^{h.}\ 40'\ 12''$	$5^{h.}\ 4'\ 19''$	$3^{h.}\ 53'\ 15''$ or $13''$
End.	5 19 48	5 25 12	5 25 $11\frac{1}{2}$	6 13 25	

	Marſeilles,	Padua,	Milan,	Cadiz,	Toulouſe,
Beg.	4 12 0	4 41 46	4 29 9	3 18 53	3 52 27 or 24 or 22
End.	6 1 46	6 21 41	6 12 0	5 26 25	

As the beginning only was obſerved at Paris, I have taken the obſervations made at Greenwich, where the end as well as the beginning of the eclipſe was ſeen.

The moon's latitude north increasing,		19′	20″,	7
The sun's horary motion,		2	23,	0
The moon's horary motion in long. in the ecliptic,		37	36,	3
The moon's horary motion in latitude,		3	9,	8
The moon's horizontal parallax,		61	7,	6
The sun's horizontal parallax,			8,	4
The sun's right ascension,	93°	20	36	
The right ascension of the mid-heaven,	148	23	21	
Angle pPZ,	121	36	39	
	= 58	23	21	
Complement	31	36	39	
The sun's semi-diameter,		15	47	
The moon's horizontal semi-diameter,		16	40,	3
The obliquity of the ecliptic,	23	28	6	
PZ, &c. as before,				

Hence

The altitude of the nonagesimal degree,		54	13	45
Angle PpZ,		41	5	7
The longitude of the nonagesimal degree,	4	11	5	7
Angle Zp☽ = B,		37	58	35
The moon's parallax in longitude from the sun,			30	47, 6
The moon's parallax in latitude from the sun,			35	50, 1
The moon's augmented semi-diameter,			16	51, 8
The sum of ☉'s & ☽'s semi-diam.—4″,5 for infl. = ☉☽,				1954″,3
The moon's visible lat. from the sun = E☽				989, 4
The visible diff. of long. of ☉'s and ☽'s centers ☉E,				1685, 3
			= 28′	5″,3
The moon's ecliptic long. by observation,	3ˢ. 3°	6	44,	3

At

At the Royal Obfervatory at Greenwich, at $5^{h.} 25' 12''$ apparent time.

The fun's longitude,	$3^{s.} 3^{\circ}$	$8'$	$12''$,2	
The moon's ecliptic longitude,	3 4	12	21,	0
The moon's latitude north,		42	52,	8
The fun's right afcenfion,	93	25	8	
The right afcenfion of the mid-heaven,	174	43	8	
Angle pPZ,	95	16	52	
	= 84	43	8	
Complement	5	16	52	

Hence

The altitude of the nonagefimal degree,		46	11	19	
Angle PpZ		59	45	50	
The longitude of the nonagefimal degree,	4	29	45	50	
Angle Zp☽ $=$ B,		55	33	29	
The moon's parallax in longitude from the fun,			36	33,	5
The moon's parallax in latitude from the fun,			42	20,	7
The moon's augmented femi-diameter,			16	47,	8
The fum of ☉'s & ☽'s femi-diam.—4'',5 for infl. = ☉☽,				1950'',	3
The moon's vifible lat. from the fun = E☽,				1047,	9
The vifible diff. of long. of ☉'s and ☽'s centers = ☉E,				1644,	9
			= 27'	24'',	9
The moon's ecliptic long. by obfervation,	$3^{s.} 4^{\circ}$	12	10,	6	

Hence it appears, that the motion of the moon by obfervation, during the eclipfe, with refpect to the ecliptic, was $1^{\circ} 5' 26'',3$; but, by Mayer's tables, it was $1^{\circ} 5' 49''$. Suppofing then the horary motion by the tables to be true, as is moft probable, we may conclude, that there is an error in the moon's latitude,

latitude, as given by them, the correction of which may be found, in the manner following:

	s	°	′	″
The ☽'s longitude at the beginning, per tables,	3	3	6	32,0
The ☽'s parallax in longitude from ☉			— 30	47, 6
	3	2	35	44, 4
The ☽'s longitude at the end per tables,	3	4	12	21, 0
The ☽'s parallax in longitude from ☉			— 36	33, 5
	3	3	35	47, 5
Subtract	3	2	35	44, 4
Difference		1	0	3, 1
Subtract ☉'s motion during the eclipse,			4	10, 2
Remains ☽'s visible motion from ☉ per tables,			55	52, 9
			60	
			3352,	9
The ☽'s visi. lat. from ☉ by calculation at beginning,				989″,4
At the end,				1047, 9
The ☽'s visible motion in latitude from the ☉,*				58, 5

In plate I. fig. I. let E☉C be a portion of the ecliptic § = 3352″,9 the moon's visible motion from the sun, during the eclipse.

* The moon's visible motion as it arises from her horary motion and parallaxes in latitude, is not affected by the small error in the latitude given by the tables.

§ See note, page 17.

eclipſe. Let ☽E be = the moon's viſible latitude from the ſun, at the beginning of the eclipſe, and CL the ſame at the end. Let ☽M be drawn parallel to E⊙C; then, ML = 58″.5 will be the moon's viſible motion in latitude from the ſun, during the eclipſe, and M☽L, the viſible angle of the moon with the ſun in the ecliptic.* Let ☽⊙ be the diſtance of the ⊙'s and ☽'s centers, at the beginning of the eclipſe, and ⊙L the ſame at the end; then the point at ⊙ will be the place of the ecliptic conjunction; and the line ⊙D, perpendicular to the ecliptic, and cutting the moon's viſible path ☽L in D, will be the moon's viſible latitude from the ſun, at the time of the ecliptic conjunction; and the line ⊙N, perpendicular to the viſible path, and cutting it in N, will be the leaſt diſtance of centers.

☽M	3352″,9	3	5254206
: ML	58, 5	1	7675269
:: Radius		10	
: Tangent angle M☽L,	1° 0′ 2″	8	2421063
Sine angle M☽L,	1 0 2	8	2420401
: ML	58, 5	1	7675269
:: Radius		10	
: ☽L	3353, 4	3	5254868
☽L	3353″,4	3	5254868
: ☽⊙+L⊙	3904, 6	3	5915796
:: ☽⊙—L⊙	4, 0	0	6020600
: Difference ☽N and LN	4, 6	0	6681528
	G		½☽

* The true ſide ML is ſo ſhort in this ſmall figure, that it was neceſſary to increaſe it for the ſake of illuſtration; but every one knows that the calculations are not affected by it, the true length being uſed in them.

½☽L	1676″,7		
½ difference ☽N and LN	+— 2, 3		
☽N	1679, 0		
LN	1674, 4		
☽☉	1954, 3	3	2909912
: Radius		10	
:: ☽N	1679, 0	3	2250507
: Sine angle ☽☉N	59° 13′ 9″	9	9340595
Angle N☽D = M☽L	+ 1 0 2		
Angle ☽☉D = ☽☉F	60 13 11		
	90		
Angle ☽☉E	29 46 49		
Radius		10	
: ☽☉	1954″,3	3	2909912
:: Sine angle ☽☉E	29° 46′ 49′	9	6959990
: E☽	970, 5	2	9869902
☽'s visible lat. from ☉ =	16′ 10, 5 S		
From ☽'s parallax in lat. from ☉	35 50, 1		
Sub. ☽'s visi. lat. from ☉ now found	16 10, 5		
Remains ☽'s correct latitude,	19 39, 6 N		
☽'s lat. by Mayer's tables,	19 20, 7 N		
Error of the tables in ☽'s lat.	— 18, 9*		

* As the time both of the beginning and end of the eclipse is used in deducing this error, there is no need of finding CL, which would give the same.

Thus it appears, by the Greenwich obſervations of the beginning and end of this eclipſe, that the latitude of the moon, given by Mayer's tables, is 18″, 9 too ſmall,* which correction, being applied, will give her latitude at the beginning 19′ 39″, 6, and at the end 25′ 11″, 7. Hence the viſible difference of longitude, at the beginning, was 28′ 16″, 3, and at the end 27′ 36″, 7; and the true longitude by obſervation $3^{s.}$ 3° 6′ 33″, 3 and $3^{s.}$ 4° 12′ 22″, 4, the difference being 1° 5′ 49″, as by the tables. The true difference of longitude between the ſun and moon, at the beginning, was 151″, 3, the moon's longitude being the greateſt: Therefore, ☽'s horary motion from ☉ 2113″,3 : 1 hour = 3600″ :: 151″,3 : $257\frac{3}{4}$″ = 4′ $17\frac{3}{4}$″; which being ſubtracted from $3^{h.}$ 40′ 11″ (the obſerved time of the beginning of the eclipſe at Greenwich) becauſe the moon had really paſſed the conjunction, leaves $3^{h.}$ 35′ $53\frac{1}{4}$″ for the apparent time of the true ecliptic conjunction.

Let us now aſſume $4^{h.}$ 44′ 4″ for the difference of meridians between Greenwich and Chelſea, and find the elements for Chelſea, at the end of the eclipſe, viz. At $11^{h.}$ 38′ 23″, anſwering to $4^{h.}$ 22′ 27″ at Greenwich, according to this aſſumption.

At Chelſea at $11^{h.}$ 38′ 23″, A. M. apparent time.

The ſun's longitude,	$3^{s.}$	3°	5′	42″,8
The moon's ecliptic longitude,	3	3	33	1, 8

G 2 The

* By the Oxford obſervations of the beginning and end of this eclipſe, the error in latitude, in Mayer's tables, was — 20″, 6, differing but 0″, 7 from the error found by the Greenwich obſervations.

The moon's lat. corrected by the Greenwich obſerva.	21 53, 2
The moon's horizontal parallax,	61 10, 0
The ſun's right aſcenſion,	93 22 25
The right aſcenſion of the mid-heaven	87 58 10
Angle pPZ,	177 58 10
	= 2 1 50
Complement	87 58 10
The latitude of Chelſea,	42 25 11
Reduced to the center,	42 10 20
Complement = PZ	47 49 40

Hence

The altitude of the nonageſimal degree,	71 17 6
The longitude of the nonageſimal degree,	2 28 24 40
Angle $Zp☽ = B$	5 8 21
The moon's parallax in longitude from the ſun,	5 15, 8
The moon's parallax in latitude from the ſun,	19 32, 6
The ſum of ☉'s & ☽'s ſemi-diam.—4″,5 for infl. = ☉☽,	1959″,8
The moon's viſible latitude from the ſun,	140, 6
The viſible diff. of long. of ☉'s and ☽'s centers = ☉E	1954, 7
	= 32′ 34″,7
The moon's ecliptic long. by obſervation,	$3^{s.}$ 3° 33 1, 7
The true diff. of long. of ☉ and ☽ according to the aſſumption,	27 18, 9
	= 1638″,9

☽'s horary motion from ☉ 2113″, 3 : 1 hour = 3600″, :: 1638″, 9 : 2792″ = 46′ 32″. Subtract 46′ 32″ from $11^{h.}$ 38′ 23″, the time of the end of the eclipſe at Chelſea, and the remainder $10^{h.}$ 51′ 51″, A. M. will be the time when the true

true ecliptic conjunction happened. This subtracted from $3^{h.}$ $35' 53\frac{1}{4}''$, P. M. the time of the true ecliptic conjunction at Greenwich, leaves $4^{h.}$ $44'$ $2\frac{1}{4}''$ for the difference of meridians between these two places. To this add $26''$, the difference of meridians between Cambridge and Chelsea; the sum, $4^{h.}$ $44'$ $28\frac{1}{4}''$ will be the difference between Cambridge and Greenwich, by the observations of this eclipse.

Deductions from the observations of a transit of Mercury, November 5, 1743, for determining the difference of meridians between Paris* and Cambridge.

At Paris, November 5, 1743, a transit of Mercury was observed by

		1st. inter. contact. Apparent time.
Mr. Maraldi,	At the Royal Observatory,	$8^{h.}$ $40'$ $46''$
Mr. Cassini, jun.	At the Royal Observatory,	8 40 34
The Abbe de la Caille, at College Mazarin,		8 40 38
Mr. Cassini, sen. at Thury,		8 40 31
	The mean,	8 40 $37\frac{1}{4}$

	2d. inter. contact.	2d. exter. contact.
Mr. Maraldi,	$1^{h.}$ $10'$ $17''$	1 12 18
Mr. Cassini, jun.	1 10 26	1 12 24
The Abbe de la Caille,	1 10 3	1 11 58
Mr. le Monnier, jun. near Port St. Honore,	1 9 $54\frac{1}{2}$	1 12 2

Mr.

* A bad state of the atmosphere prevented this transit from being observed at Greenwich.

Mr. Caſſini, ſen.	1h. 10′ 28″	*
Mean,	1 10 13⅓	1 12 10½

Hence it appears, that at the egreſs, Mercury was about 1′ 57″ in making his tranſit acroſs the ſun's limb, the half of which, viz. 58½″, added to the time of the ſecond internal contact, will give 1h. 11′ 12″, P. M. for the time of the central contact, at the egreſs; and, ſubtracted from the time of the firſt internal contact, will give the central contact at the ingreſs 8h. 39′ 38¾″, A. M.

N. B. The place where Mr. Caſſini, ſen. obſerved is 6″ in time eaſt of the meridian of the Royal Obſervatory; the place where Mr. le Monnier, jun. obſerved, 2″ weſt. The times obſerved by them are here adjuſted to the meridian of the Obſervatory. The place where the Abbe de la Caille made his obſervations is ſo near to the meridian of the Royal Obſervatory, that the difference in time is imperceptible.

At 8h. 39′ 38¾″, A. M. apparent time, at the Royal Obſervatory of Paris.

The ſun's longitude,	7s. 12°	32′	57″,205	
Mercury's geocentric ecliptic longitude,	7 12	45	5, 688	
Mercury's geocentric lat. ſouth decreaſing,		10	48, 165	
The ſun's right aſcenſion,	220	5	40	
The right aſcenſion of the mid-heaven,	170	0	21	
Angle pPZ,	99	59	39	
				= 80

* Mr. Caſſini, ſen. was doubtful of the ſecond external contact; it is therefore omitted.

		= 80° 0′21″
	Complement	9 59 39
Mercury's diſtance form the earth,	log.	4 829651
: The ſun's diſtance from the earth,	log.	4 995787
:: The ſun's horizontal parallax, 8″,58	log.	0 933487
: Mercury's horizontal parallax, 12, 578		1 099620
Mercury's horizontal parallax from the ſun,		3″,998
The ſun's ſemi-diameter,		16′ 11, 7
Mercury's ſemi-diameter,		5, 1
The ſun's horary motion,		2 30, 7
Mercury's geocen. horary mot. in the ecliptic retrog.		3 22, 12
Mercury's mot. upon ☉'s diſc with reſpect to the eclip.		5 52, 82
Mercury's horary motion in latitude geocentric,		51, 7
Latitude of the Royal Obſervatory at Paris,		48° 50 14
Reduced to the center,		48 35 26
	Complement = PZ	41 24 34

Hence

The altitude of the nonageſimal degree,	50 2 38
The longitude of the nonageſimal degree,	$5^{s.}$ 28 11 44
Angle Z*p*☿ = B,	44 33 22
Mercury's parallax in longitude from the ſun,	2, 151
Mercury's parallax in latitude from the ſun,	2, 574
The ſun's ſemi-diameter = ☉☿	971, 7
Mercury's viſible lat. from the ſun's center = E☿	650, 739
The viſi. diff. of long. of ☉'s and ☿'s centers = ☉E,	721, 484
	= 12′ 37, 434
☉'s longitude,	7 12 32 57, 205

Add

Add visi.diff.long.of ☉'s & ☿'s cent. ☿ being retro.		+ 12′		1″,4	
	7ˢ·	12°	44	58,	605
Mercury's parallax in longitude from the sun,			—	2,	151
Mercury's true long. by observation,	7	12	44	56,	454
The true diff.long.☉'s & ☿'s cen.by obs.at 8ʰ· 39′38½″,			11	59,	249
			60		
				719,	249

N. B. The above references are to Plate I. Fig. I. and IV. ☽ being supposed changed for ☿. The various processes are similar to those made in the foregoing solar eclipses.

At 1ʰ· 11′ 12″ the time of the central contact of ☿ at the egress.

The sun's longitude,	7ˢ·	12°	44′	19″,	258
Mercury's geocentric ecliptic longitude,	7	12	29	50,	909
Mercury's geocentric latitude south,			6	54,	174
The sun's right ascension,		220	16	58	
The right ascension of the mid-heaven,		238	4	58	
Angle pPZ		31	55	2	
Complement		58	4	58	

Hence

The altitude of the nonagesimal degree,		24	16	35	
The longitude of the nonagesimal degree,	7	1	43	37	
Angle Zp☿ = B,		10	46	13	
Mercury's parallax in longitude from the sun,				0,	307

Mercury's

Mercury's parallax in latitude from the sun, 3″,647
☉ ☿ as before, 971, 7
Mercury's visible lat. from the sun's center = E ☿ 417, 821
The visible diff. of long. of ☉'s and ☿'s centers = ☉E 877, 284
= 14′ 37, 284
Mercury's true ecliptic long. by observation, $7^{s.}$ 12° 29 41, 667

Hence it appears, that Mercury's motion in geocentric longitude in the ecliptic, by observation, from his central contact at the ingress, to his central contact in the egress, was 15′ 14″, 787. According to the horary motion in the elements, from whence the calculations were made, it was 15′ 14″, 779. We may therefore take the motion given in the elements, as the true, and say, 5′ 52″, 82 = 352″, 82 Mercury's horary motion upon the sun's disc with respect to the ecliptic : 1 hour = 3600″ :: 719″, 249 the true difference of longitude of ☉'s and ☿'s centers at the central contact at the ingress : 7339″ = $2^{h.}$ 2′ 19″. This added to $8^{h.}$ 39′ 38$\frac{1}{7}$″, the time of Mercury's central contact at the ingress, will give $10^{h.}$ 41′ 57$\frac{1}{7}$″, A. M. apparent time, for the true ecliptic conjunction, by observation.

The same transit was observed by Professor Winthorp,* at Cambridge, who saw the second internal contact at $8^{h.}$ 17′ 5″,

H A. M.

* Professor Winthrop, in a letter to Dr. Bliss, Astronomer Royal, dated 20th June, 1763, and published in vol. LIX, of the Philosophical Transactions, communicates his observations of this transit, with the express design of settling the longitude of Cambridge, by comparing them with the European ones; and he gives it as his opinion, that it might thereby be determined with more exactness, than by any observations that had been made use of, for that purpose.

He

A. M. apparent time, and the ſecond external contact at $8^{h.}$ 18′ 58″; which makes the contact of Mercury's center, at the egreſs, at $8^{h.}$ 18′ $1\frac{1}{2}$″, A. M.

Suppoſe the difference of meridians between Paris and Cambridge to be $4^{h.}$ 53′ 45″, then it was $1^{h.}$ 11′ $46\frac{1}{2}$″, P. M. at Paris, when it was $8^{h.}$ 18′ $1\frac{1}{2}$″, A. M. at Cambridge.

Elements at $1^{h.}$ 11′ $46\frac{1}{2}$″, P. M. at Paris, anſwering to $8^{h.}$ 18′ $1\frac{1}{2}$″, A. M. at Cambridge.

The ſun's longitude,	$7^{S.}$ 12°	44′	20″,701
Mercury's geocentric ecliptic longitude,	7 12	29	48, 968
Mercury's geocentric latitude ſouth,		6	53, 679
The ſun's right aſcenſion,	220	17	0
The right aſcenſion of the mid-heaven,	164	47	22
Angle *p*PZ,	105	12	38
	= 74	47	22
Complement	15	12	38
PZ, as before,	47	51	23
Hence			
The altitude of the nonageſimal degree,	57	27	17
The longitude of the nonageſimal degree,	4 28	4	43
Angle Z*p*☿ = B,	74	25	5
Mercury's parallax in longitude from the ſun,			3, 246

Mercury's

He informs Dr. Bliſs, that his clock was adjuſted by correſpondent altitudes of the bright ſtar of Aries, taken the night before the tranſit, with a quadrant of two feet radius; and on the day of the tranſit, by correſpondent altitudes of the ſun; all which agreed within 5″; and that he allowed for the difference of the ſun's declination morning and afternoon.

Mercury's parallax in latitude from the ſun,	2″,154
☉☿,	971, 7
Mercury's viſi. lat. from the ſun's center = E☿,	415, 833
The viſi. diff. of long. of ☉'s and ☿'s centers = ☉E,	878, 227
	= 14′ 38, 227
From the ſun's longitude,	$7^{s.}$ 12° 44 20, 701
Subtract the viſi. diff. of long. of ☉'s & ☿'s centers,	14 38, 227
	7 12 29 42, 474
Subtract ☿'s parallax in longitude from ☉,	3, 246
Remains ☿'s geocent. eclip. long. by obſerv. accord. to the aſſumed diff. of meridians,	7 12 29 39, 228
The true diff. long. ☉'s & ☿'s cent. by obſerva. at $8^{h.}$ 18′ 1½″, A. M.	14 41, 473
	60
	881, 473

352″, 82 : 3600″ :: 881″, 473 : 3994″ = $2^{h.}$ 29′ 54″.

Therefore,

From the time of ☿'s central contact by obſervation at Cambridge, at the egreſs,	$8^{h.}$ 18′ 1½″, A.M.
Subtract	2 29 54
Rem. the time of the true ecliptic conj. by obſ.	5 48 7½, A. M.
The time of the true ecliptic conjunction at Paris by obſervation,	10 41 57¼, A. M.
Difference = the difference of meridians between Paris and Cambridge,	4 53 50¼

Sub. the diff. of merid. betw. Paris & Greenwich,	—	9′	16″, A.M.
Remains the difference of meridians between Greenwich and Cambridge,	$4^{h.}$	44	$34\frac{1}{4}$
The diff. by the observations of the solar eclipse of August 5, 1766,	4	44	$29\frac{1}{2}$
Do. by the obs. of the sol. eclipse of June 24, 1778,	4	44	$28\frac{1}{4}$
The mean	4	44	$30\frac{2}{3}$
Therefore, avoiding fractions, the difference of meridians may be called	4	44	31 ‡

‡ In a letter to the present Astronomer Royal, published in the volume of the Philosophical Transactions for 1781, I made the difference of meridians between Cambridge and Greenwich, by the solar eclipse of Aug. 1766, to be $4^{h.}\ 44'\ 22''$; and by the transit of Venus of June, 1769, to be $4^{h.}\ 44'\ 12''$, comparing Mr. Hitchins's observation of the internal contact only, with Dr. Winthorp's. The mean of these two results, viz. $4^{h.}\ 44'\ 17''$, I gave as the true difference. But as the sun was low, when the observations of the transit were made at Greenwich, which caused an uncertainty attending them, not experienced where the altitude was considerable and the atmosphere clear, I have supposed it not expedient to make use of the result from this phenomenon, in the foregoing paper.

In making my deductions from the solar eclipse of 1766, in the above appendix, I have taken the mean between the time of the observations of the Astronomer Royal, and of his assistant; whereas, in the former calculations, I took those only of the Astronomer Royal. I have also used $42^{\circ}\ 23'\ 28''$, for the latitude of Cambridge, as determined by Professor Williams, instead of $42^{\circ}\ 25'$; and with these alterations, having carefully gone over the work anew, I have found the difference of meridians, from this eclipse, $4^{h.}\ 44'\ 29\frac{1}{2}''$, instead of $4^{h.}\ 44'\ 22''$.

The deductions from the transit of Mercury, and the solar eclipse of 1778, were not made, when the above letter was written.

I supposed it proper to add this note, to shew the reason of the difference between the result in this paper, and that in the letter published in the Philosophical Transactions.

I have been particular, in this appendix, in putting down the deductions from the obſervations which I have made uſe of, in ſettling the longitude of Cambridge from Greenwich, that any perſons, who may meet with this paper, and are able to go thro' this kind of calculation, may ſee what ſtreſs is to be laid upon the determinations. If the deductions are right, the near agreement between the three reſults is a ſtrong evidence of the goodneſs of the obſervations, and the dependence that may be made upon the mean reſult, for the difference of meridians between Greenwich and Cambridge; which, perhaps, is now aſcertained to as great exactneſs as the difference between almoſt any two places, where terreſtrial meaſurement has not been made uſe of.

J. W.

II. *A Memoir on the Latitude of the University at Cambridge : With Observations of the Variation and Dip of the Magnetic Needle.* *By* SAMUEL WILLIAMS, *F. A. A. Hollis Professor of Mathematics and Natural Philosophy in the University.*

I. THE latitude of Cambridge has generally been supposed to be 42° 25′ north. I cannot find how early, by what observer, or with what instruments it was determined. The earliest observations at Cambridge of which I can find any account, were those of eclipses made by Mr. *Thomas Brattle*, mentioned in *the Philosophical Transactions* for 1704, No. 292. p. 1630. The first of these was of a solar eclipse, June 12, 1694. And he there informs us, that in his calculations, the latitude of *Boston* was allowed to be 42° 25′. This has been universally received as the latitude ever since that time, and probably for many years before. As the ancient instruments belonging to the College were but small, I was desirous to examine this matter with all the accuracy I could. With this view I made the following observations. They were taken in the Philosophy-Chamber in Harvard-Hall, with an astronomical quadrant of two feet and an half radius, made by *Sissons*.

I. The

1. The latitude of the University at Cambridge, computed from observations of the meridian altitude of the sun's upper limb.

Time.	Observation of the meridian altitude ☉'s upper limb.	Refraction.	☉'s Semidiameter.	Parallax.	☉'s Declination South.	Latitude of the University.
1782.						
Oct. 9	41° 24′ 30″	1′ 15″	16′ 5″,0	6″	6°29′35″	42° 23′ 21″
10	41 1 39	1 16	16 5,3	6	6 52 23	42 23 25,3
11	40 39 3	1 17	16 5,5	6	7 15 5	42 23 20,5

By a mean of these observations the latitude is. 42° 23′ 22″,3

2. The latitude of the University computed from observations of the meridian altitude of stars near the Equator.

Observations of the meridian altitude of

Time.	δ In the wing of the *Eagle.*	π In the shoulder of *Antinous*	θ In the hand of *Antinous.*	β In the shoulder of *Aquarius.*	α In the shoulder of *Aquarius.*	γ In the Arm of *Aquarius.*
1782.						
Oct. 9	50°19′ 9″	48°5′ 35″	° ″ ″	° ′ ″	° ″ ″	° ′ ″
12	50 19 51	48 5 57	46 10 34			
23		48 5 48	46 10 50			
Nov. 1			46 10 33			
3				41 7 8	46 15 45	45 9 35
4				41 6 53	46 15 33	45 9 20
5				41 6 53	46 15 34	45 9 18
Mean,	50 19 30	48 5 46,6	46 10 39	41 6 58	46 15 37,3	45 9 24,3

CALCULATIONS.

δ in the wing of the *Eagle*.

Mean of merid. altitudes taken Oct. 9, 12, 1782,	50°	19′	30″
Refraction by De la Caille's tables,		—	55
True meridian altitude,	50	18	35
Declin. N. Jan. 1, 1782, by *Connoi. des Temps*, 1782,	2	41	55

Increase

Increase of declination in 9, 5 months,	+			5″,1
Aberration,	+			8, 6
Nutation,	—			8, 6
Apparent declination N. Oct. 11, 1782,		2°	42′	0, 1
Complement of the latitude,		47	36	34, 9
Latitude,		42	23	25, 1

* in the shoulder of *Antinous*,

Mean of merid. altitudes taken Oct. 9, 12, 28, 1782,		48	5	47
Refraction,	—		1	0
True meridian altitude,		48	4	47
Declin. N. Jan. 1, 1782, by *Connoi. des Temps*, 1782,		0	28	4
Increase of declination in 9, 5 months,	+			6, 7
Aberration,	+			7, 5
Nutation,	—			8, 3
Apparent declination N. Oct. 16, 1782,		0	28	9, 9
Complement of the latitude,		47	36	37, 1
Latitude,		42	23	22, 9

θ in the hand of *Antinous*.

Mean of meridian altitudes taken Oct. 12, 23, and November 1, 1782,		46	10	39
Refraction,	—		1	4
True meridian altitude,		46	9	35
Declin. S. Jan. 1, 1782, by *Connoi. des Temps*, 1782,		1	26	57
Decrease of declination in 9, 5 months,	—			7, 8
Aberration,	—			6, 3
Nutation,	+			8, 0
Apparent declination S. Oct. 22, 1782,		1	26	50, 9
Complement of the latitude,		47	36	25, 9
Latitude,		42	23	34, 1

β in

β in the shoulder of *Aquarius*.

Mean of merid. altitudes taken Nov. 3, 4, 5, 1782,	41°	6'	58"	
Refraction,	—	1	16	
True meridian altitude,	41	5	42	
Declin. S. Jan. 1, 1782, by *Connoi. des Temps*, 1782,	6	30	59	
Decrease of declination in 10 months,	—		12,	5
Abberation,	—		3,	5
Nutation,	+		6,	3
Apparent declination S. Nov. 4, 1782,	6	30	49,	3
Complement of the latitude,	47	36	31,	3
Latitude,	42	23	28,	7

α in the shoulder of *Aquarius*.

Mean of merid. altitudes taken Nov. 3, 4, 5, 1782,	46	15	37	
Refraction,	—	1	4	
True meridian altitude,	46	14	33	
Declin. S. Jan. 1, 1782, by *Connoi. des Temps*, 1782,	1	22	5	
Decrease of declination in 10 months,	—		14,	3
Aberration,	—		5,	4
Nutation,	+		5,	2
Apparent declination S. Nov. 4, 1782,	1	21	50,	5
Complement of the latitude,	47	36	23,	5
Latitude,	42	23	36,	5

γ in the arm of *Aquarius*.

Mean of merid. altitudes taken Nov. 3, 4, 5, 1782,	45	9	24	
Refraction,	—	1	6	
True meridian altitude,	45	8	18	
Declin. S. Jan. 1, 1782, by *Connoi. des Temps*, 1782,	2	28	33	
Decrease of declination in 10 months,	—		14,	8

Aberration,	—			5″
Nutation,	+			4, 6
Apparent declination S. Nov. 4, 1782,		2°	28′	17, 8
Complement of the latitude,		47	36	35, 8
Latitude,		42	23	24, 2

The latitude by the meridian altitude of

δ in the *Eagle*,	42	23	25, 1
π in *Antinous*,			22, 9
θ in *Antinous*,			34, 1
β in *Aquarius*,			28, 7
α in *Aquarius*,			36, 5
γ in *Aquarius*,			24, 2
By a mean of these observations the latitude is	42	23	28, 6

3. The latitude of the University computed from observations of the meridian altitude of the pole-star.

Observations of the meridian altitude of the pole-star, below the pole.

1783.	May	27	40°	33′	22″
		28	40	33	25
		29	40	33	35
	June	5	40	33	22
Mean altitude,			40	33	26

Calculation.

Mean of merid. altitudes taken May 27, 28, 29, and June 1, 1783. Below the pole.		40	33	26
Refraction by De la Caille's tables,	—		1	17
True meridian altitude,		40	32	9
Declin. N. Jan. 1, 1782, by *Connoi. des Temps*, 1782,		88	8	28

Increase

Increaſe of declination in one year,	+	19″,6
Increaſe of declination in 5 months,	+	8, 2
Aberration,	—	17, 0
Nutation,	+	2, 5
Apparent declination N. June 1, 1783,		88° 8′ 41, 3
Diſtance from the pole,		1 51 18, 7
Latitude,		42 23 27, 7

From theſe calculations the latitude computed

1. From obſervations of the ſun, is	42 23 22, 3
2. From obſervations of ſix ſtars near the Equator,	42 23 28, 6
3. From obſervations of the pole-ſtar,	42 23 27, 7

In making the above obſervations I found it much eaſier to note the biſection of a ſtar by the wire of the teleſcope, than to determine exactly the point of contact between the limb of the ſun and the wire. On this account I eſteem the obſervations of the meridian altitude of the ſtars more accurate than thoſe of the ſun: And therefore fix upon the mean of all the *ſidereal obſervations* as the true

Latitude of Harvard-Hall at Cambridge, 42° 23′ 28″, 46

A REMARK.

The preceding obſervations will ſerve to determine the accuracy of the quadrant, as well as the latitude of the place. For this purpoſe I ſhall ſelect the obſervations which were made on β in the ſhoulder of *Aquarius*, and thoſe of the pole ſtar.

Apparent declination of β S.		6° 30′ 49,″3
Apparent declin. of the pole-ſtar N. 88° 8′ 41, ″3		
Diſtance from the pole.	1 51 18, 7	91 51 18, 7
Below the pole at the time of obſerv.	1 51 18, 7	

True meridian altitude of β,	41° 5′ 42″
True meridian altitude of the pole-ſtar,	40 32 9
Sum of the declinations and altitudes,	179 59 59

Hence it appears, that the ſum of all the errors in the aſſumed declinations of theſe two ſtars, in the refraction, quadrant, and mean altitudes, do not amount to more than one ſecond. It may therefore be preſumed that the quadrant, obſervations, and elements of the calculations are very exact. The reaſon why the obſervations on β in *Aquarius* were choſen to examine the quadrant by, was becauſe they are nearer the mean latitude than thoſe of any other ſtar, and therefore may be preſumed to be the moſt correct.

II. Obſervations of the variation and dip of the magnetic needle, at the Univerſity in Cambridge.

Time. Year. Mon. D. H.	Variation. ° ′	Dip. ° ′	Obſerver.
1708,	9 0 W		Mr. Brattle,
1742,	8 0 W		Dr. Winthorp.
1757,	7 20 W		Dr. Winthorp.
1761, Feb. 25,	7 14 W		Mr. Williams.
1763,	7 0 W		Dr. Winthorp.
1780, Dec. 25, 1, P. M.	7 2 W	69 51	Mr. Williams.
1782, June 21, 4, P. M.	6 46 W	69 41	Mr. Williams.
1783, Dec. 23, 3, P. M.	6 52 W	69 41	Mr. Williams.

In the year 1782, Profeſſor Sewall obſerved the diurnal variation of the magnetic needle during ſeveral months. At the

the ſame time I obſerved the diurnal alterations in the dipping needle. Theſe obſervations are too numerous to be inſerted here. In general, there is a remarkable regularity in the obſervations taken by the variation needle. The variation generally increaſes from ſeven or eight o'clock, A. M. till about two or three, P. M. From this time it generally decreaſes until ſeven or eight the next morning. The inclination or dip is ſubject to rather greater diurnal alterations than the variation; but they do not ſeem to be ſo regular in their changes. The leaſt inclination I have ever obſerved was 68° 21′; the greateſt 70° 56′.

III. *A Table of the Equations to equal Altitudes, for the Latitude of the University of* Cambridge, 42° 23′ 28″ N. *with an Account of it's Construction and Use. By the Reverend* JOSEPH WILLARD, *President of the University.*

THE regulation of a clock, which is made use of for astronomical purposes, is of the utmost importance. Unless it's going is accurately ascertained, the observations made by it, however excellent in other respects, can be of no use. Every thing, therefore, which tends to facilitate it's regulation, is worthy of attention.

The best method to ascertain the going of a clock, where a person has not a transit instrument fixed in the meridian, is by equal altitudes of the sun, taken by some instrument adapted to the purpose. Hadley's octant is the most easily obtained; and double altitudes may be taken by it, by reflection from a bowl of some liquid, which will not be easily put into motion by the air. The oil of tar, or very clean molasses will answer the purpose well.

The method is, to take the altitude of the sun's upper or lower limb, or both, in the morning as far from noon as may be convenient, and note the time by the clock to a second. The time must be noted in the afternoon, when the altitude is the same. Then, add half the interval between the two observations, to the time of the morning observation, which will give the time by the clock, nearly, when the sun's center passed the

the meridian. This would be the apparent noon exactly, if the sun did not alter his declination: But as this is constantly varying, a small equation, arising from the change of declination between the forenoon and afternoon observations, must be applied to the time of noon thus found, except at the solstices, when the variation is too small to make any equation necessary.

ILLUSTRATION.

In Plate I. Fig. VI. let EPQL be the hour circle of six o'clock, and ECQ a portion of the Equator. Let P be the north-pole, L the south; and PZL the meridian of some place. Let the arc *lZt* mark the latitude of a given place: Then, the point Z will be it's zenith; and the arc HOR will be a portion of the horizon, O being 90° distant from Z. Let the arc *mxg* mark the sun's declination, in the morning, at a time when his altitude is taken, and *avn* the declination in the afternoon, when his altitude is the same as in the morning observation. Let the angle ZP☉ be the distance of the sun from the meridian, at the time of the morning observation = the half interval between the forenoon and afternoon observations, nearly; then side PZ will be the co-latitude of the place, the side P☉ the sun's co-declination, and the side Z☉ the sun's co-altitude or zenith distance. Let the co-altitude Z☉ be set off from Z to *r*, a point in the arc of the sun's declination, at the time of the forenoon observation, and through *r* draw the arc P*r*L. Let Z☉ also be set off from Z to S, a point in the arc of the sun's declination, at the time of the afternoon observation, and through S draw the arc PSL. Then, it will be evident,

dent, that when the sun has the same zenith distance in the afternoon observation that he had in the forenoon, he will be further distant from the meridian by the space pq, measured upon the Equator, equal to the angle pPq. Bisect the angle ⊙PS, and draw the pricked arc PbL, (the same as adding the half interval to the time of the forenoon observation) which shews the mean noon; but it is as much after the apparent noon, or the true time of the sun's passing the meridian, as the space Cb upon the Equator, which is equal to half pq. The time answering to Cb, therefore, must, in this case, be subtracted from the mean noon, which will reduce it to the meridian PCL, or, which is the same thing, give the true time when the sun passed the meridian, by the clock. This equation, Cb, may easily be found trigonometrically, by the triangles P⊙Z and PSZ.

EXAMPLE.

At Cambridge, latitude 42° 23′ 28″ N. suppose the altitude of the sun taken April 2, 1783, at 8h. 40′, A. M. i. e. at 3h. 20′, or 50°, from the meridian, and the corresponding altitude taken in the afternoon; required the equation to the corresponding altitudes?

April 2, 1783, at 8h. 40′, A.M. ⊙'s declination,	5° 1′ 00″	Com. = P⊙	84°	59′	0″
At 3h. 20′, P. M. ditto,	5 7 22	Com. = PS	84	52	38
Co-latitude,		= PZ	47	36	32
Angle ZP⊙ = 3h. 20′		=	50	0	0

In

In the triangle ZP⊙, given sides PZ and P⊙, and the included angle ZP⊙, to find side Z⊙ the co-altitude or zenith distance of the sun at the time of observation ? *Zi* is perpendicular to P⊙.

Radius,					
: Sine co-angle ZP⊙	40°	0′	0″	9	8080675
:: Tangent PZ	47	36	32	10	0396048
: Tangent segment P*i*	35	9	6	9	8476723 :
P⊙	84	59	0		
Diff. = segment ⊙*i*	49	49	54		
Sine Co-P*i*	54	50	54	9	9125573
: Sine Co-⊙*i*	40	10	6	9	8095836
:: Sine Co-PZ	42	23	28	9	8287809
: Sine Co-Z⊙	32	7	55	9	7258072
Z⊙ = ZS	57	52	5		

In the triangle ZPS are given the three sides to find angle ZPS.

PZ	47	36	32	
PS	84	52	38	
ZS = Z⊙	57	52	5	
Sum of sides	190	21	15.	
½ sum	95	10	37,	5
½ sum—PZ	47	34	5,	5
½ sum—PS	10	17	59,	5

PZ	Sine	47°	36′	42″		9	8683857
x PS	Sine	84	52	38		9	9982618
						19	8666475
: Radius square,						20	
:: ½ sum of sides—PZ = Sine		47	34	5, 5		9	8681039
x ½ sum of sides—PS = Sine		10	17	59, 5		9	2523671
: Sine of square of ½ ∠ ZPS					2	19	2538235
Sine of ½ ∠ ZPS		25	3	33, 7		9	6769117
				x 2.			
Angle ZPS		50	7	7, 4			
Subtract ZP☉		50					
Remains space pq, or angle pPq			7	7, 4			
				x 4			
Reduced to time,			28″	29‴, 6			
The ½ of which is Cb = the equation to the equal altitudes,			14	14, 8			

This method is accurate, but tedious; and to shorten the work, formulas have been invented. One deduced by Mr. William Wales from art. 256 of Simpson's Fluxions is, perhaps, as easy and concise as any. It is divided into two parts. The first is composed of the change in the sun's declination, during half the interval between the observations, multiplied by the co-secant of the sun's horary angle at the times of the observations,

tions, multiplied again by the tangent of the geographical latitude. The second part consists of the said change in the declination, multiplied by the tangent of the sun's declination, multiplied again by the co-tangent of the sun's horary angle. When the sun's declination is north, this second part of the equation is to be subtracted from the first; but when it is south, it is to be added to it; and the difference or sum will be the equation to the equal altitudes: Which equation is additive, when the sun is declining southward; i. e. when the declination is north decreasing or south increasing; but when the contrary, it is subtractive.

These rules are to be observed, when the latitude is north: They must be inverted, when it is south.

The exactness of this formula will appear, by making use of the foregoing example.

Whole change in declination $6' 22''$. Half do. $3' 11''$ added to $5° 1' 0''$, the declination at the time of the morning observation, gives $5° 4' 11''$ for ☉'s declination at noon.

Half change of declin.	$3' 11'' = 191''$	2 2810334
x Secant of co-hour angle,	40° 0' 0	10 1157460
x Tangent of the latitude,	42 23 28	9 9603952
First part of the equation,	227, 6	2 3571746

Half change declination	191''	2 2810334
x Tangent declination,	5° 4' 11	8 9479970
x Tangent co-hour angle,	40 0 0	9 9238135
Second part of the equation,	14, 2	1 1528439
Which subtracted from the first part,	227, 6	
Leaves the equat. to the equal altitudes,	213, 4	
	= 3 33, 4	
	x 4	
The equation in time,	14'' 13''', 6	

By this formula was the following table calculated; but it is to be observed, that the sun's longitude, instead of the declination answering to it, is put down for the argument, as being the most convenient.

A

A TABLE of the EQUATIONS to equal Altitudes. For Lat. 42° 23′ 28″ N.

	Half Interval between the Obfervations.															
longitude.	H. M. II 0	H. M. II 10	H. M. II 20	H. M. II 30	H. M. II 40	H. M. II 50	H. M. III 0	H. M. III 10	H. M. III 20	H. M. III 30	H. M. III 40	H. M. III 50	H. M. IV 0	H. M. IV 10	H. M. IV 20	H. M. IV 30
S. D.	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴
0 — 0	14.25	14.33	14.41	14.49	14.58	15. 7	15.16	15.27	15.40	15.54	16. 7	16.22	16.38	16.55	17.13	17.33
5	13.52	14. 0	14. 9	14.18	14.27	14.37	14.47	14.59	15.12	15.26	15.40	15.56	16.13	16.31	16.51	17.12
10	13.13	13.22	13.31	13.40	13.50	14. 0	14.11	14.24	14.39	14.54	15. 9	15.25	15.43	16. 2	16.23	16.44
15	12.31	12.41	12.51	13. 1	13.11	13.21	13.32	13.46	14. 1	14.17	14.32	14.49	15. 7	15.26	15.47	16.10
20	11.45	11.55	12. 5	12.15	12.26	12.37	12.49	13. 3	13.18	13.33	13.50	14. 7	14.26	14.46	15. 8	15.30
25	10.56	11. 6	11.16	11.27	11.38	11.49	12. 2	12.16	12.31	12.46	13. 3	13.21	13.40	14. 0	14.23	14.46
I — 0	10. 6	10.16	10.26	10.36	10.47	10.59	11.12	11.25	11.40	11.55	12.12	12.30	12.50	13.11	13.33	14.56
5	9. 4	9.23	9.34	9.44	9.55	10. 7	10.19	10.32	10.48	11. 3	11.20	11.38	11.58	12.19	12.40	13. 2
10	8.21	8.30	8.40	8.50	9. 1	9.12	9.25	9.39	9.54	10. 8	10.25	10.42	11. 1	11.21	11.41	12. 4
15	7.27	7.36	7.46	7.55	8. 6	8.17	8.29	8.42	8.56	9.10	9.26	9.44	10. 3	10.22	10.42	11. 3
20	6.35	6.43	6.52	7. 1	7.11	7.21	7.33	7.45	7.59	8.13	8.28	8.44	9. 2	9.20	9.39	9.58
25	5.43	5.50	5.58	6. 7	6.16	6.26	6.37	6.49	7. 1	7.13	7.27	7.41	7.57	8.14	8.32	8.50
II — 0	4.52	4.58	5. 5	5.12	5.20	5.29	5.39	5.50	6. 2	6.13	6.25	6.38	6.52	7. 7	7.23	7.40
5	4. 0	4. 6	4.13	4.20	4.27	4.35	4.43	4.52	5. 2	5.11	5.21	5.32	5.44	5.57	6.11	6.26
10	3.10	3.15	3.21	3.27	3.33	3.39	3.46	3.53	4. 0	4. 7	4.16	4.26	4.36	4.47	4.49	5.12
15	2.22	2.25	2.29	2.33	2.38	2.43	2.48	2.53	2.59	3. 5	3.12	3.19	3.27	3.36	3.46	3.55
20	1.33	1.35	1.38	1.41	1.44	1.48	1.52	1.56	2. 0	2. 3	2. 7	2.12	2.18	2.24	2.30	2.37
25	0.45	0.46	0.47	0.49	0.51	0.53	0.55	0.57	0.59	1. 1	1. 3	1. 5	1. 8	1.11	1.15	1.19
III + 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0
5	0.45	0.46	0.47	0.49	0.51	0.53	0.55	0.57	0.59	1. 1	1. 3	1. 5	1. 8	1.11	1.15	1.19
10	1.33	1.35	1.38	1.41	1.44	1.48	1.52	1.56	2. 0	2. 3	2. 7	2.12	2.18	2.24	2.30	2.37
15	2.22	2.25	2.29	2.33	2.37	2.42	2.47	2.52	2.59	3. 5	3.12	3.19	3.27	3.36	3.45	3.55
20	3. 9	3.14	3.19	3.24	3.30	3.37	3.44	3.51	3.59	4. 6	4.15	4.26	4.36	4.47	4.49	5.11
25	3.58	4. 4	4.11	4.18	4.25	4.33	4.41	4.49	4.58	5. 7	5.18	5.30	5.42	5.55	6. 9	6.24
IV + 0	4.50	4.57	5. 4	5.11	5.19	5.28	5.38	5.48	5.59	6.10	6.22	6.36	6.50	7. 6	7.20	7.36
5	5.43	5.50	5.58	6. 6	6.15	6.24	6.35	6.46	6.59	7.11	7.25	7.40	7.56	8.13	8.31	8.49
10	6.34	6.42	6.50	6.59	7. 9	7.20	7.31	7.43	7.56	8. 9	8.24	8.40	8.58	9.16	9.35	9.56
15	7.26	7.34	7.43	7.52	8. 2	8.13	8.25	8.38	8.52	9. 6	9.22	9.39	9.57	10.16	10.37	10.59
20	[illegible].19	8.27	8.36	8.46	8.57	9. 9	9.22	9.36	9.50	10. 4	10.21	10.38	10.56	11.16	11.38	11.59
25	9. 9	9.18	9.28	9.39	9.50	10. 1	10.13	10.27	10.42	10.57	11.14	11.31	11.50	12.11	12.33	12.56
V + 0	10. 1	10.10	10.20	10.30	10.41	10.53	11. 6	11.20	11.35	11.49	12. 6	12.24	12.43	13. 3	13.25	13.48
5	10.51	11. 0	11. 9	11.19	11.30	11.42	11.55	12. 9	12.24	12.39	13.56	13.14	13.33	13.53	14.15	14.38
10	11.39	11.48	11.57	12. 7	12.18	12.29	12.41	12.55	13.10	13.24	12.56	13.59	14.18	14.38	15. 0	15.22
15	12.24	12.33	12.42	12.52	13. 3	13.14	13.25	13.38	13.52	14. 8	14.23	14.40	14.58	15.17	15.38	15.59
20	13. 8	13.15	13.23	13.32	13.42	13.53	14. 4	14.16	14.30	14.45	14.59	15.15	15.32	15.51	16.12	16.33
25	13.43	13.51	14. 0	14.10	14.20	14.30	14.40	14.51	15. 4	15.18	15.31	15.46	16. 2	16.20	16.40	17. 1
VI + 0	14.17	14.24	14.32	14.40	14.49	14.59	15. 8	15.19	15.31	15.44	15.57	16.12	16.28	16.45	17. 3	17.22

A TABLE of the EQUATIONS to equal Altitudes. For Lat. 42° 23′ 28″ N.

Half Interval between the Observations.

☉'s longitude.	H. M. II 0	H. M. II 10	H. M. II 20	H. M. II 30	H. M. II 40	H. M. II 50	H. M. III 0	H. M. III 10	H. M. III 20	H. M. III 30	H. M. III 40	H. M. III 50	H. M. IV 0	H. M. IV 10	H. M. IV 20
S. D.	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴
VI + 0	14.17	14.24	14.32	14.40	14.49	14.59	15. 8	15.19	15.31	15.44	15.57	16.12	16.28	16.45	17. 3
5	14.44	14.51	14.58	15. 6	15.15	15.24	15.33	15.43	15.54	16. 6	16.18	16.32	16.47	17. 3	17.20
10	15. 6	15.12	15.18	15.25	15.33	15.42	15.50	16. 0	16.10	16.21	16.32	16.45	16.59	17.13	17.28
15	15.21	15.27	15.33	15.39	15.45	15.52	15.59	16. 8	16.18	16.29	16.39	16.51	17. 4	17.17	17.31
20	15.29	15.33	15.38	15.44	15.50	15.56	16. 2	16.11	16.20	16.30	16.39	16.49	17. 0	17.12	17.25
25	15.28	15.32	15.37	15.42	15.47	15.53	15.59	16. 5	16.12	16.20	16.28	16.37	16.47	16.57	
VII + 0	15.17	15.21	15.25	15.29	15.36	15.39	15.43	15.49	15.56	16. 3	16.10	16.18	16.26	16.36	
5	14.58	15 0	15. 3	15. 6	15.10	15.15	15.19	15.24	15.30	15.36	15.41	15.48	15.56		
10	14.30	14.32	14.34	14.36	14.39	14.42	14.45	14.50	14.55	15. 0	15. 4	15.10	15.16		
15	13.46	13.47	13.48	13.50	13.52	13.55	13.58	14. 2	14. 7	14.12	14.16	14.21			
20	12.52	12.53	12.55	12.57	12.59	13. 2	13. 4	13. 7	13.10	13.13	13.15				
25	11.47	11.48	11.49	11.50	11.51	11.53	11.56	11.59	12. 2	12. 5					
VIII + 0	10.31	10.31	10.32	10.33	10.34	10.36	10.38	10.40	10.43						
5	9. 4	9. 4	9. 5	9. 6	9. 7	9. 8	9. 9	9.10	9.12						
10	7.29	7.29	7.30	7.30	7.31	7.31	7.32	7.32	7.33						
15	5.45	5.45	5.45	5.46	5.46	5.46	5.46	5.47	5.47						
20	3.51	3.51	3.51	3.52	3.52	3.52	3.52	3.53	3.53						
25	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	2. 0						
IX — 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0						
5	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	2. 0						
10	3.51	3.51	3.51	3.52	3.52	3.52	3.52	3.53	3.53						
15	5.45	5.45	5.45	5.46	5.46	5.46	5.46	5.47	5.47						
20	7.30	7.30	7.31	7.31	7.32	7.32	7.33	7.33	7.34						
25	9. 6	9. 6	9. 7	9. 8	9. 9	9.10	9.11	9.12	9.14						
X — 0	10.33	10.35	10.35	10.36	10.37	10.39	10.41	10.43	10.45						
5	11.51	11.52	11.53	11.54	11.56	11.58	12. 0	12. 3	12. 6	12. 9					
10	12.58	12.59	13. 0	13. 1	13. 2	13. 4	13. 5	13. 8	13.12	13.17	13.21				
15	13.53	13.54	13.55	13.56	13.58	14. 0	14. 2	14. 6	14.11	14.16	14.20	14.26			
20	14.34	14.36	14.38	14.41	14.45	14.49	14.52	14.56	15. 0	15. 5	15. 9	15.15	15.22		
25	15. 5	15. 7	15.10	15.13	15.17	15.22	15.26	15.31	15.37	15.43	15.49	15.56	16. 4		
XI — 0	15.25	15.29	15.33	15.37	15.42	15.48	15.53	15.59	16. 6	16.13	16.19	16.27	16.36	16.45	
5	15.35	15.39	15.44	15.49	15.55	16. 1	16. 7	16.15	16.23	16.31	16.35	16.46	16.48	17. 8	
10	15.36	15.41	15.46	15.52	15.59	16. 6	16.13	16.52	16.31	16.41	16.46	16.58	17. 1	17.22	17.34
15	15.29	15.35	15.41	15.47	15.54	16. 2	16.10	16.19	16.29	16.39	16.49	17. 1	17.14	17.27	17.41
20	15.14	15.21	15.28	15.36	15.46	15.52	16. 0	16. 9	16.19	16.30	16.41	16.54	17. 8	17.23	17.39
25	14.53	15. 0	15. 8	15.16	15.25	15.34	15.42	15.52	16. 3	16.15	16.27	16.41	16.56	17.12	17.29
0 — 0	14.25	14.33	14.41	14.49	14.58	15. 7	15.16	15.27	15.40	15.54	16. 7	16.22	16.38	16.55	17.13

The uſe of the foregoing table will appear eaſy by an example.

April 12, 1782, the following correſponding double altitudes of the ſun were taken at Cambridge with Hadley's octant.

	D. Alt.	Foren. Obſ.	Afternoon.	Interval.	½ Interval.	Mean Noon.
Sun's upper limb.	54°00′	7h 56′ 27″	4h 11′ 0″	8h 14′ 33″	4h 7′ 16½″	12h 3″ 43″ 30‴
	58 00	8 7 33	3 59 50	7 52 17	3 56 8½	12 3 41 30
Sun's lower limb.	59 20	8 14 18	3 53 0	7 38 42	3 49 21	12 3 39 00
	61 20	8 20 3	3 47 22	7 27 19	3 43 39	12 3 42 30
Mean noon by the clock by the above obſervations,						12 3 41 37
Equation by the table for change of declina. during the ½ interval,						—13 49
Apparent time by clock when ☉'s center paſſed the meridian,						12 3 27 48

Hence, we find that the clock was 3′ 27″ 48‴ too faſt for apparent time.

The mean ½ interval to theſe correſponding altitudes is $3^{h.}$ 54′ 6″. The ſun's longitude at noon, on the above day, was, at Paris, by *Connoiſance des Temps*, $0^{S.}$ 22° 40′; therefore, allowing for the difference of meridians, it was at Cambridge, $0^{S.}$ 22° 52′. Hence, by taking the proportion in the table between the equations for the ½ interval $3^{h.}$ 50′ and $4^{h.}$ 0′, and for the longitudes $0^{S.}$ 20° and $0^{S.}$ 25°, for the ½ interval $3^{h.}$ 54′ 6″ and the longitude $0^{S.}$ 22° 52′, we shall find 13″ 49‴, as in this example.

The

The table of equations to equal altitudes is calculated for latitude 42° 23′ 28″; but by adding or ſubtracting the following ſmall equations, or proportional parts of them, the general equations may be found, as far as two degrees in latitude more or two degrees leſs. Theſe ſmall equations are put down with their ſign for the ſun's longitudes, the half intervals and the latitudes to which they are calculated; and they need no explanation.

				½ Intervals.			½ Intervals.	
				2h.	4h. 30′		2h.	4h. 30′
			° ′ ″	‴	‴	° ′ ″	″ ‴	″ ‴
S. 0	S. 0	S. 0	Lat. 41 23 28 N	Equ. — 30	— 36.	Lat. 40 23 28	Equ. — 59	— 1 11
☉'s long. 0	0 & VI. 0		Lat. 43 23 28	+ 31	+ 37.	Lat. 44 23 28	+ 1 2	+ 1 17
☉'s long. I. 15	IV. 15		Lat. 41 23 28	— 21	— 26.	Lat. 40 23 28	— 42	— 51
VII. 15 & X. 15			Lat. 43 23 28	+ 22	+ 27.	Lat. 44 23 28	+ 45	+ 55

IV. *Astronomical Observations, made in the State of* Massachusetts. *By Professor* WILLIAMS.

Observations of the eclipses of the sun and moon, in the years 1761, and 1764; and from 1770 to 1784.

1. An observation of a lunar eclipse, November 12, 1761, at *Waltham*.

THE weather was so cloudy that I could only make the following observations of this eclipse.—

		Temp. app.
The shadow reached	*Kepler,*	$16^{h.} 59' 0''$
	Mare Vaporum,	17 7 40
	Tycho,	14 25
	Menelaus,	17 28
	Mare Crisium,	28 11
Total immersion,		45 10

2. An observation of a lunar eclipse, March 17, 1764, at *Waltham*.

The moon rose behind a cloud that lay along the horizon, but soon began to appear: About $6^{h.} 10'$ I saw her considerably eclipsed: *Tycho* was then covered.

The shadow reached	*Nectaris,*	$6^{h.} 30'$
	Copernicus,	32
	Mare Vaporum,	43
	Menelaus,	55

 Archimedes,

The ſhadow reached	*Archimedes*,	56′
	Mare Criſium,	7h. 3
covers	*Mare Criſium*,	17
	Tycho begins to appear,	8 12
leaves	*Mare Criſium*,	21
End of the eclipſe,		39 54″

Theſe obſervations were made with a reflecting teleſcope about four feet in length : And the clock was adjuſted by a meridian line, and correſponding altitudes of the ſun.

3. An obſervation of a ſolar eclipſe, November 6, 1771, at *Bradford*.

The beginning of this eclipſe could not be obſerved, the weather being cloudy. At 1h. 36′ 42″, it was evident that the eclipſe was begun. The clouds prevented alſo any obſervation of the quantity of the eclipſe : But I had a good obſervation of the end, which was at 3h. 47′ 2″ apparent time.

4. An obſervation of a lunar eclipſe, April 6, 1773, at *Bradford*.

		Temp. app.
Beginning of the eclipſe,		14h. 32′ 38″
The ſhadow reaches	*Grimaldus*,	40 43
	Mare Humorum,	41 53
covers	*Mare Humorum*,	47 38
reaches	*Tycho*,	52 23
	Kepler,	15 1 28
	Copernicus,	11 20
	Mare Tranquillitatis,	27 13
	Mare Fœcunditatis,	32 54

Mare

The shadow reaches	*Mare Serenitatis,*	42′ 15″
	Mare Crisium,	58 8
leaves	*Mare Crisium,*	16h. 43 23
	Mare Humorum,	45 23
	Mare Tranquillitatis,	52 25
	Tycho,	59 38
End of the eclipse,		17 20 10

The last observation was attended with some uncertainty ;—the moon being near the horizon, and the day-light far advanced.

5. An observation of a lunar eclipse, July 30, 1776, at *Bradford.*

This eclipse was total : But the beginning of it, and the beginning of total darkness were invisible at *Bradford*, both happening before the moon rose. I was in hopes to have seen the end of total darkness, but was prevented by clouds. At $8^{h.}\ 30'$ the sky became perfectly clear, so that I had a good observation of the end of the eclipse, which was at $9^{h.}\ 2'\ 44''$.

6. An observation of a solar eclipse, June 24, 1778, at *Bradford.*

The beginning of this eclipse could not be observed, the sun being wholly covered with clouds. At $10^{h.}\ 8'$ they broke away : And though often interrupted afterwards, I was able to note the following phenomena.

About $10^{h.}\ 16'$, the horns of the sun were observed to have an equal altitude, being in a line parallel to the horizon. At $10^{h.}\ 23'$ the lucid parts of the sun amounted to $2'\ 45''$; whence,

 as

as the ſun's apparent diameter was 31′ 34″, the eclipſed parts were 28′ 49″, or 10 digits and 57 minutes. This was very near the time of the greateſt obſcuration: But whether it was exactly ſo I could not determine, the ſun being obſcured juſt before and after this obſervation. At $10^{h.}$ 25′ a large ſpot emerged from the ſhadow. At $10^{h.}$ 59′ four other large ſpots were wholly within the lucid part. At the end of the eclipſe the ſky was become clear, and by a good obſervation I found this to be at $11^{h.}$ 38′ 16″ apparent time.

During the eclipſe, there was a very ſenſible alteration in the ſtate of the *air*. A chill, and a damp were very generally felt. The mercury in the thermometer at $9^{h.}$ 4′, juſt before the eclipſe began, was at 67°½. At $10^{h.}$ 20′, it fell to 66°. At the end of the eclipſe it roſe to 73°; and at noon it was at 74°½.

As the time of the greateſt obſcuration came on, that part of the ſky, which was free from clouds, changed from an azure blue, to a more dark and duſky colour: And the dew fell ſo faſt as to wet the paper we were uſing to a conſiderable degree.

As this eclipſe was *total* in ſome of the *ſouthern ſtates*, I was very deſirous to have it carefully obſerved in ſeveral places, in hope that a ſufficient number of obſervations might be collected to determine the exact path and limits of the ſhadow: And it was with much regret that I found myſelf prevented by the weather from making a more compleat obſervation.

7. An obſervation of a lunar eclipſe, December 3, 1778, at *Bradford*.

Beginning

		Temp. app.		
Beginning of the eclipse,		11h.	41′	14″
The shadow reaches	*Mare Serenitatis,*	12	6	6
	Copernicus,		13	53
	Mare Tranquillitatis,		23	12
	Mare Crisium,		28	15
leaves	*Mare Imbrium,*	13	47	0
	Mare Serenitatis,		54	0
	Mare Crisium,		59	30
End of the eclipse,		14	5	20

These observations were made in a very favourable state of the air.

8. An observation of a lunar eclipse, and an emersion of Jupiter's second satellite, May 29, 1779, at *Bradford.*

The emersion of the satellite was at		8	58	13
Beginning of the eclipse,		10	15	41
The shadow touches	*Tycho,*		35	15
	Copernicus,		40	35
	Mare Serenitatis,	11	0	6
	Mare Crisium,		18	15
Beginning of total darkness,			28	39
End of total darkness,		12	50	41
The shadow leaves	*Tycho,*	13	27	7
	Mare Serenitatis,		38	57
	Mare Crisium,		54	49
End of the eclipse,		14	3	51

During

During the whole time of this eclipſe, the weather was very favourable for obſervation. All the obſervations made at *Bradford*, were taken with a reflector made by *Nairne*, magnifying about 55 times. The times were ſhewn by a good clock, carefully adjuſted by equal altitudes of the ſun, the day before and the day after the eclipſe.

9. Obſervations of a ſolar eclipſe, October 27, 1780, made on the eaſt ſide of *Long-Iſland*, in *Penobſcot-Bay*.

A total eclipſe of the ſun is a curious and uncommon phenomenon. From the principles of aſtronomy it is certain that a central eclipſe will happen, in ſome part of the earth, in the courſe of every year: But it is but ſeldom that a total eclipſe of the ſun is ſeen in any particular place. A favourable opportunity preſenting for viewing one of theſe eclipſes on October 27, 1780, the American Academy of Arts andSciences, and the Univerſity at Cambridge, were deſirous to have it properly obſerved in the eaſtern parts of the State, where, by calculation, it was expected it would be total. With this view they ſolicited the government of the Commonwealth, that a veſſel might be prepared to convey proper obſervers to *Penobſcot-Bay*; and that application might be made to the officer who commanded the *Britiſh* garriſon there, for leave to take a ſituation convenient for this purpoſe.

Though involved in all the calamities and diſtreſſes of a ſevere war, the government diſcovered all the attention and readineſs to promote the cauſe of ſcience, which could have been expected in the moſt peaceable and proſperous times; and paſſed a reſolve, directing the Board of War to fit out the

Lincoln

Lincoln galley to convey me to *Penobſcot*, or any other port at the eaſtward, with ſuch aſſiſtants as I ſhould judge neceſſary.

Accordingly, I embarked October 9, with Mr. Stephen Sewall, Profeſſor of the Oriental Languages, James Winthrop, Eſq; Librarian, Forteſque Vernon, A. B. and Meſſ'rs. Atkins, Davis, Hall, Dawſon, Renſalear, and King, Students in the Univerſity. We took with us an excellent clock, an aſtronomical quadrant of $2\frac{1}{2}$ feet radius, made by *Siſſons*, ſeveral teleſcopes, and ſuch other apparatus as were neceſſary.

On the 17th we arrived in *Penobſcot-Bay*. The veſſel was directed to come to anchor in a cove on the eaſt ſide of *Long-Iſland*. After ſeveral attempts to find a better ſituation for obſervations, we fixed on this place as the moſt convenient we had reaſon to expect :* And on the 19th we put our inſtruments on ſhore, ſet up the clock and quadrant in a building facing towards the ſouth, near the houſe of Mr. *Shubael Williams*, where the following obſervations were made.

OCTOBER 20.

Correſponding altitudes of the ſun taken with a reflector fitted with vertical and horizontal wires.

Time

* As the officer who commanded at *Penobſcot*, in his anſwer to the application of the government, had limitted us to a time wholly inadequate to our purpoſe, from the 25th to the 30th of October, we were obliged to make a ſecond application for leave to enter *Penobſcot-Bay* Leave was granted, but with a poſitive order to have no communication with any of the inhabitants, and to depart on the 28th, the day after the eclipſe. Being thus retarded and embarraſſed by military orders, and allowed no time after the eclipſe to make any obſervations, it became neceſſary to ſet up our apparatus and begin our obſervations without any further loſs of time. In the courſe of which, we received every kind of aſſiſtance fromCapt.*Henry Mowatt*, of the Albany, which it was in his power to give.

Time by the clock.

Eastern az.			Western az.			Meridian.		
8h.	15′	44″	3h.	54′	43″	12h.	5′	13″,5
	21	58		48	28			13
	28	48		41	34			11
	31	30		38	57			13, 5
Mean,						12	5	12, 75
Equation of altitudes,						+		17, 50
⊙'s center on the meridian,						12	5	30, 25
Clock too fast,							5	30, 25

Meridian altitude of the sun's upper limb, taken with the astronomical quadrant, 35° 15′ 45″

OCTOBER 21.

Corresponding altitudes of the sun taken with a reflector.

Time by the clock.

Eastern az.			Western az.			Meridian.		
8h.	15′	11″	3h.	58′	20″	12h.	6′	45″,5
	18	45		54	46			45, 5
	21	35		51	52			43, 5
	28	28		45	5			46, 5
	32	7		41	23			45
	35	17		38	12			44, 5
	45	53		27	36			44, 5
Mean,						12	6	45
Equation of altitudes,						+		17, 5
⊙'s center on the meridian,						12	7	2, 5
Clock gains in 24 hours,							1	32, 25

OCTOBER

OCTOBER 22.

Thick fog all day. No aſtronomical obſervations. At $8^{h.}$ 15′, A. M. I put the clock back 15′, and lengthened the pendulum.

OCTOBER 23.

Thick fog all day. No aſtronomical obſervations.

OCTOBER 24.

Correſponding altitudes of the ſun, taken with the quadrant.

Time by the clock.

Eaſtern az.			Weſtern az.			Meridian.		
$8^{h.}$	1′	47″	$3^{h.}$	44′	58″	$11^{h.}$	53′	22″,5
	4	55		41	52			23, 5
	7	58		38	54			26
	11	31		35	23			27
	14	57		31	51			24

Mean,	11	53	24, 60
Equation of altitudes,	+		16, 75
☉'s center on the meridian,	11	53	41, 35
Clock too ſlow,		6	58, 65

Meridian altitude of the ſun's upper limb, 33°51′43″

In the night I obſerved the meridian altitude of

Rigel,	37 16 15
Sirius,	29 19 0
Procyon,	51 30 26

OCTOBER 25.

Correſponding altitudes of the ſun, taken with the quadrant.

Time by the clock.

Eastern az.			Western az.			Meridian.		
8h.	31′	17″	3h.	17′	19″	11h.	54′	18″
	35	4		13	31			17, 5
	36	43		11	53			18
	38	16		10	20			18
	42	4		6	28			16
	45	16		3	16			16
	46	0		2	33			16, 5
	47	38		0	53			15, 5
	49	16	2	59	11			13, 5
	57	16		51	8			12
	59	3		49	25			14
9	0	39		47	47			13

Mean,	11	54	15, 66
Equation of altitudes,	+		16, 63
☉'s center on the meridian,	11	54	32, 29
Clock too slow,		5	27, 71
Clock gains in 24 hours,			50, 94

Meridian altitude of the sun's upper limb,	33°	31′	4″
In the night I observed the meridian altitude of			
Rigel,	37	16	15
Sirius,	29	19	6
Procyon,	51	30	30

OCTOBER 26.

Corresponding altitudes of the sun, taken with the quadrant.

Time

Time by the clock.

Eastern az.			Western az.			Meridian.		
8h.	30′	56″	3h.	19′	13″	11h.	55′	4″,5
	32	31		17	41			6
	34	3		16	5			4
	34	45		15	26			5, 5
	36	25		13	46			5, 5
	37	56		12	13			4, 5

Mean,	11	55	5
Equation of altitudes,	+		16, 53
☉'s center on the meridian,	11	55	21, 53
Clock too flow,		4	38, 47
Clock gains in 24 hours,			49, 24

OCTOBER 27.

Correfponding altitudes of the fun, taken with the quadrant.

Time by the clock.

Eastern az.			Western az.			Meridian.		
8h.	7′	18″	3h.	44′	30″	11h.	55′	54″
	8	32		43	15			53, 5
	9	14		42	32			53
	10	48		40	56			52
	12	6		39	40			53
	15	41		36	15			58
	17	23		34	26			54, 5
	18	33		33	13			53
	19	23		32	25			54
	20	56		30	48			52
	24	11		27	36			53, 5

Eastern az.		Western az.		Meridian.
25′	25″	26′	18″	51″,5
26	21	25	33	57
29	39	22	16	57, 5
31	12	20	36	54
33	21	18	28	54, 5
35	5	16	48	56, 5
36	27	15	26	56, 5

Mean,	$11^{h.}$	55′	54, 33
Equation of altitudes,	+		16, 40
☉'s center on the meridian,	11	56	10, 73
Clock too slow,		3	49, 27
Clock gains in 24 hours,			49, 20

Observations of the Eclipse.

Four persons observed the solar eclipse with me. Professor Sewall, James Winthorp, Esq; Mess'rs. Dudley Atkins, and John Davis, two young gentlemen of the University, who had made good proficiency in mathematical studies, and been pretty constantly employed in making observations for several days before.

At $8^{h.}$ 20′, A. M. with an object-glass micrometer applied to a reflecting telescope of twelve inches focus, made by *Short*, I measured the sun's diameter parallel to the horizon, and by a mean of ten observations, I found it 32′ 17″, 33.

With a reflecting telescope of two feet focal length, made by *Short*, and a magnifying power of ninety times, I observed the beginning of the eclipse at $11^{h.}$ 11′ 8″.

Soon

Soon after I had noted the beginning, I adjuſted the micrometer to the direction of the ſhadow; and during the increaſe of the eclipſe, made the following obſervations on the quantity.

App. time.			Lucid Parts by the Micrometer.			Lucid Parts reduced.		App. time.			Lucid Parts by the Micrometer.			Lucid Parts reduced.	
			Rev.	Parts.	Diviſ.						Rev.	Parts.	Diviſ.		
h.	′	″				′	″	h.	′	″				′	″
11	27	58	1	11	16	25	12, 8	12	0	48		17	19	12	17, 9
	29	1		10	16	24	31, 8		4	0		16	10 d	11	18, 3
	30	12		9	12	23	42, 5		6	52		13	7	9	8, 8
	33	38		8	7	22	51, 0		9	3		12	2	8	17, 4
	35	49		7	18	22	32, 6		12	48		10	15	7	21, 9
	38	14		5	12	20	57, 9		13	38		9	16	6	42, 8
	42	24		3	4	19	19, 3		17	26		7	2	4	51, 9
	45	24		1	6	18	1, 2		19	36		6	17 d	4	41, 5
	49	36	0	23	15	16	16, 3		21	24		5	14 d	3	54, 3
	51	53		22	7	15	18, 8		22	51		4	18	3	21, 4
	54	33		21	18	15	0, 3		25	13		2	10	1	42, 7
	56	16		19	13	13	27, 8		26	50		1	13	1	7, 8
	58	35		18	7	12	34, 4		28	48			12		24, 7

Immediately after the laſt obſervation, the ſun's limb became ſo ſmall as to appear like a circular thread, or rather like a very fine horn. Both the ends loſt their acuteneſs, and ſeemed to break off in the form of ſmall drops or ſtars; ſome of which were round, and others of an oblong figure. They would ſeparate to a ſmall diſtance: Some would appear to run together again, and others diminiſh until they wholly diſappeared. Finding it very difficult to meaſure the lucid part any longer, I obſerved again in the larger teleſcope, looking out for the total immerſion. After viewing the ſun's limb about a minute, I found almoſt the whole of it thus broken or ſeparated in drops, a ſmall part only in the middle remaining connected. Plate I. Fig. VII. This appearance remained about a minute, when one of my aſſiſtants, who was looking at the ſun with his naked eye, ob-

ſerved

ſerved that the light was increaſing. At this time I could not ſee any appearance of an increaſe of the lucid part. At $12^{h.}$ $31' \, 18''$, it was evident that the broken parts of the ſun's limb began to increaſe and unite. I immediately applied to the micrometer and meaſured the chord of the lucid part, and found it amounted to $42°$ or $43°$: This was from the extremity of each limb taken from the moſt diſtant parts that were viſible. I then meaſured the connected part of the limb, and found it to be $24°$ or $25°$. As the light and limb were by this time very ſenſibly increaſing, I again began to meaſure the quantity of the lucid part, and made the following obſervations with the micrometer.*

App. time.			Lucid Parts by the Micrometer.			Lucid Parts reduced.		App. time.			Lucid Parts by the Micrometer.			Lucid Parts reduced.	
			Rev.	Parts.	Divis.						Rev.	Parts.	Divis.		
h.	′	″				′	″	h.	′	″				′	″
12	33	36	0	1	11	1	3, 7		6	10		21	1	14	25, 3
	35	48		3	1	2	5, 3		12	29	1	0	0	17	7, 8
	38	13		4	8	3	0, 8		14	5		1	7	18	8, 3
	40	18		5	13	3	52, 2		17	53		3	5	19	21, 4
	45	24		8	15	5	59, 7		21	5		5	0	20	33, 3
	47	21		10	19	7	30, 1		24	46		7	7	22	9, 9
	49	7		11	2	7	36, 3		30	12		10	12	24	23, 5
	51	55		12	11	8	35, 9		33	12		12	8	25	37, 5
	54	13		14	17	10	10, 4		35	41		14	19	27	22, 3
	56	15		15	3	10	22, 7		39	6		16	19	28	44, 6
	58	0		16	5	11	8, 0		42	25		18	19	30	6, 8
1	2	59		19	5	13	11, 4		46	31		20	7	31	4, 4

The quantity of the lucid part being now become ſo large, I prepared to obſerve the end : And with the ſame teleſcope which I uſed at the beginning, I obſerved the end of the eclipſe at $1^{h.} \, 50' \, 25''$.

From

* I ſuſpect there muſt be ſome inaccuracy in theſe obſervations. Some months after, upon examining the micrometer with which they were taken, I found ſome parts of it had been diſplaced.

From these observations it may be inferred, that the greatest obscuration was at 12$^{h.}$ 30' 12'': At which time the sun's limb was reduced to so fine a thread, and so much broken as to be incapable of mensuration.

Professor Sewall observed with an achromatic telescope of 4 feet, made by *Dolland*, magnifying 40 times.

The beginning by his observation was at 11$^{h.}$ 11' 38''. The end was not accurately ascertained, being disturbed in his observations by some of the spectators.

Mr. Winthrop observed with a reflecting telescope, made by *Nairne*, magnifying 55 times.

The beginning by his observation was at	11$^{h.}$	11'	38''
Shadow touches the spots on the N. W. limb,		29	28
Spots totally immersed,		30	0
Shadow touches the first spot in the western limb,		44	6
central spot,		46	8
eastern spot,		47	9
End of the eclipse,	1.	50	17 to 21''

D. Atkins observed the beginning and end of the eclipse with a reflecting telescope of 12 inches focus, made by *Short*, magnifying about 55 times. His other observations were made with the telescope which I used to observe the beginning and end of the eclipse. The following is his account of his observations.

Beginning of the eclipse,	11	11	13

The

	h.	'	''
The ſhadow touched the center of a large ſpot on the weſtern ſide of the ſun's diſc, - -	11	30	12
The ſhadow touched the center of a long cluſter of ſpots on the weſtern ſide of the ſun's center, - -		44	7
The ſhadow biſects the large ſpot in the ſun's center,		46	24
The ſpot on the eaſtern limb of the ſun half immerſed,	12	27	1
The ſpot on the eaſtern limb of the ſun half emerged,		40	18
The long cluſter of ſpots on the weſtern ſide of the ſun half emerged, - - - -		40	28
The central ſpot half emerged, - -	1	7	1
The ſhadow left the center of the ſpot on the weſtern ſide,		43	4
End of the eclipſe, - - - -	1	50	28

J. Davis obſerved with the teleſcope on the quadrant. It gives a very diſtinct viſion; but it's magnifying power is but ſmall. His account of his obſervations is as follows.

Beginning, - - - - -	11	11	16
Shadow firſt touched the largeſt ſpot in the cluſter on the N. W. limb, - - - -		29	10
wholly covered the ſame, - -		30	9
Shadow firſt touched a large ſpot near the center of the ſun's diſc, - - - -		46	14
wholly covered it, - -		46	53
Firſt ſpot began to appear, - - -	12	39	54
wholly free of the ſhadow, - -		41	13
Central ſpot firſt appeared, - - -	1	6	25
free of the ſhadow, - -		7	14
Shadow leaves the ſun, - - -	1	49	58

To

To have a comparative view of the ſeveral obſervations, they are ſet down together in the following table.

Obſervers.	Beginning.	End.	Teleſcope made uſe of.	Magnifying power.
Mr. Williams,	$11^h\,11'\,8''$	$1^h\,50'\,25''$	2 feet reflector,	90
Mr. Sewall,	11 11 38		4 feet achromatic,	40
Mr. Winthrop,	11 11 38	1 50 17to21	1 foot reflector,	55
D. Atkins,	11 11 13	1 50 28	1 foot reflector,	55
J. Davis,	11 11 16	1 49 58	$2\frac{1}{2}$ feet achromatic,	ſmall.

Whilſt we were making the above obſervations, there was little wind, and no cloud to be ſeen. But the air was not perfectly clear, being a little thick, or hazy.

From the beginning of the eclipſe unto the time of the greateſt obſcuration, the *colour* and *appearance* of the ſky was gradually changing from an azure blue to a more dark or duſky colour, until it bore the appearance and gloom of night.

The degree of *darkneſs* was greater than was to be expected, conſidering the ſun was not wholly obſcured.—*Venus* appeared bright in the weſt; *Jupiter* was ſeen near the ſun; *Lucida Lyræ* near the zenith, and *Aridef* in the north-eaſt near the horizon, appeared very bright. Several others of the fixt ſtars were alſo ſeen whoſe ſituations were not particularly noted. Objects at a ſmall diſtance appeared confuſed; and we were obliged to make uſe of candles to count our clock. But as ſoon as the greateſt obſcuration was paſt, it was univerſally remarked, that the increaſe of the light was much more rapid than that of the darkneſs had been.

As the darkneſs increaſed, a *chill* and *dampneſs* were very ſenſibly felt. To aſcertain the quantity of *dew* that fell on a ſquare

 foot,

foot during the eclipse, we cut two pieces of very fine soft paper, exactly twelve inches square. Having weighed them in a nice balance, we placed them on an horizontal board in the open air. Just after the greatest obscuration we weighed one of them again, and found it's weight was increased by the *dew* that had fallen upon it, $4\frac{1}{2}$ grains *troy*. At the end of the eclipse we took up the other, and found it's weight increased by the *dew* that lay upon it, but 3 grains; $1\frac{1}{2}$ grain being evaporated as the light and heat of the sun increased. By a similar experiment, the quantity of *dew* that fell upon a square foot the night before, was found to be $6\frac{1}{2}$ grains; the night after the eclipse, 7 grains. Thus in 1 hour and 19 minutes, when the light and heat of the sun were rapidly decreasing, there fell two-thirds as much *dew* as fell the night before, or the night after the eclipse.

To determine what alteration might take place as to *heat* or *cold*, we made the following observations on Farenheit's thermometer, which was hung up in the open air, on the north side of a tree.

Time.		Therm.	Time.		Therm.
10^h	$0'$	52°	12^h	$16'$	53°
	24	$54\frac{1}{2}$		20	52
11	14	$57\frac{1}{2}$		25	51
	21	58		33	50
	26	58		42	48
	44	58		45	49
	49	57	1	24	51
	56	$56\frac{1}{2}$		29	$52\frac{2}{3}$
12	1	56		32	54
	3	55		37	55
	11	54		54	58

To

To this we may add, so unusual a darkness, dampness and chill, in the midst of day, seemed to spread a general amazement among all sorts of animals: Nor could we ourselves observe such unusual phenomena without some disagreeable feelings.

THE LATITUDE OF THE PLACE,

Computed from the observed zenith distance of the sun's upper limb.

OCTOBER 20.

Zenith distance of the sun's upper limb,		54° 44′ 15″
Refraction,	+	1 20
Sun's semi-diameter,	+	16 8
Sun's parallax in altitude,	−	7
Zenith distance of the sun's center,		55 1 36
Sun's declination, south,	−	10 44 22
Latitude, north,		44 17 14

OCTOBER 24.

Zenith distance of the sun's upper limb,		56 8 17
Refraction,	+	1 25
Sun's semi diameter,	+	16 9
Sun's parallax in altitude,	−	7
Zenith distance of the sun's center,		56 25 44
Sun's declination, south,	−	12 8 43
Latitude, north,		44 17 1

OCTOBER 25.

Zenith distance of the sun's upper limb,		56 28 56

N 2 Refraction,

Refraction,	+		1′	26″	
Sun's semi-diameter,	+		16	10	
Sun's parallax in altitude,	—			7	
Zenith distance of the sun's center,		56°	46	25	
Sun's declination, south,	—	12	29	21	
Latitude, north,		44	17	4	
Mean of the above,		44	17	6,33	

The LATITUDE computed from the observed zenith distance of several stars.

Rigel.

Mean of zenith distances, taken Oct. 24 and 25,		52	43	45
Refraction,	+		1	14, 7
True zenith distance,		52	44	59, 7
Declin. S. Jan. 1, 1770, by *Greenwich Observ.*		8	29	0, 2
Decrease in 10 years and 299 days,	—			52,78
Aberration,	—			8,29
Nutation,	—			5,20
Apparent declin. south, Oct. 25, 1780,	—	8	27	53,93
Latitude, north,		44	17	5,77

Sirius.

Mean of zenith distances, taken Oct. 24 and 25,		60	40	57
Refraction,	+		1	41, 2
True zenith distance,		60	42	38, 2
Declin. S. Jan. 1, 1770, by *Greenwich Observ.*		16	24	56, 1
Increase in 10 years and 299 days,	+			45,97
Aberration,	—			11,04

Nutation,

Nutation,	—	6",90
Apparent declin. south, Oct. 25, 1780,	—	16° 25' 24, 13
Latitude, north,		44 17 14, 07

Procyon.

Mean of zenith distances, taken Oct. 24 and 25,		38 29 32
Refraction,	+	45, 3
True zenith distance,		38 30 17, 3
Declin. N. Jan. 1, 1770, by *Greenwich Observ.*		5 47 55, 2
Decrease in 10 years and 299 days,	—	1 20, 58
Aberration,	+	4, 71
Nutation,	+	8, 10
Apparent declin. north, Oct. 25, 1780,	+	5 46 47, 43
Latitude, north,		44 17 4, 73
Mean of the above,		44 17 8, 19
Latitude from observations of the sun,		44 17 6, 38
Latitude from observations of the stars,		44 17 8, 19
Mean of both,		44 17 7, 26

In computing the latitude I have made use of the table of refractions inserted in the Greenwich observations. But from several observations I have reason to think that the refractions in *Penobscot-Bay* are not uniform and regular; but that they vary very much with the winds and weather in that uncultivated part of the country.

As to our longitude, I could have wished to have had some observations of the eclipses of Jupiter's satellites, and of the occultations

cultations of the fixed stars by the moon. But no observations of this kind could be made. Comparing my observation of the beginning and end of the eclipse with observations made at *Cambridge*, *Chelsea*, and *Beverly*, and thence computing the difference of meridians, I find our observatory on *Long-Island*, was 9′ 20″ to the east of *Cambridge*.

The longitude of the place of our observation agrees very well with what we had supposed in our calculations. But the latitude is near half a degree less than what the maps of that part of the country had led us to expect. On this account our situation, instead of falling within the limits of the total darkness, proved to be very near the southern extremity.

10. Observations of a lunar eclipse, November 11, 1780, at *Cambridge*.

The clock was regulated by equal altitudes of the sun, taken by Mr. Gannett and Mr. Mellen. At 8^h 40′, I measured the moon's diameter parallel to the horizon with an object-glass micrometer, and by a mean of seven observations, found it to be 30′45″,9.

	Temp. app.
Beginning of the eclipse, by	
Mr. Williams, with an achromatic telescope magnifying 90 times,	10^h 21′ 9″
Mr. Gannett, with a reflector magnifying 55 times,	10 21 23
J. Dawson, with a reflector magnifying 60 times,	10 21 37
End of the eclipse, by	
Mr. Williams,	13 22 22
Mr. Gannett,	13 22 21
Mr. Mellen, with a reflector magnifying 55 times,	13 22 24

At

At the time of the greateſt obſcuration the quantity of the lucid part, as near as I could meaſure it with the micrometer, amounted to 5′ 39″, 2.—But this obſervation, and thoſe made on the end of the eclipſe, muſt be viewed as attended with ſome uncertainty. The ſhadow of the earth, throughout the whole eclipſe, was very ill-defined: And from the middle to the end of the eclipſe, the moon was partly obſcured by very thin whitiſh clouds, which made it extremely difficult to diſtinguiſh the limits of the ſhadow, or the exact time when it left the moon's limb.

11. Obſervations of a lunar eclipſe, March 28, 1782, at *Cambridge*.

Three gentlemen of the Univerſity obſerved this eclipſe with me:—James Winthrop, Eſq; Librarian, John Mellen, A. M. Mathematical Tutor, and Elijah Paine, A. B. The obſervations we made were as follow.—

Mr. *Williams's* obſervations.

		Temp. app.		
Beginning of the eclipſe,		14h	13′	16″
Shadow reaches	*Tycho*,		28	58
	Grimaldus,		31	3
covers	*Grimaldus*,		37	51
reaches	*Copernicus*,	15	4	10
	Mare Tranquillitatis,		8	40
	Tycho appears,	16	26	27
leaves	*Tycho*,		28	19
	Mare Criſium,		29	25
End of the eclipſe,			53	41
End of the penumbra,			55	51

These

These observations were made with an achromatic telescope magnifying 90 times, made by *Nairne*. At $13^{h.}$ 30′, I measured the moon's horizontal diameter with an object-glass micrometer applied to a reflecting telescope of 12 inches focus, made by *Short*, and by a mean of five observations I found it 33′ 12″. The greatest obscuration was at $15^{h.}$ 34′ 33″, when the lucid part of the moon, measured by the micrometer, was 11′ 31″, amounting to 4 digits 11′: Whence the quantity of the eclipse was 7 digits 49′.

Mr. *Winthrop's* observation.

	Temp. app.		
Eclipse began,	14^{h}	13′	42″
Shade reached *Tycho*,		28	5
Tycho wholly eclipsed,		30	24
Grimaldus,		33	27
Grimaldus quite eclipsed,		37	42
Insula Ventorum eclipsed,		59	22
Copernicus,	15	4	6
Cusps horizontal,		48	59
Tycho begins to emerge,	16	26	6
quite out of the shade,		27	49
End of the eclipse,		53	15
End of the penumbra,		53	45

Mr. Winthrop observed with a reflector, made by *Nairne*, fitted with vertical and horizontal wires, magnifying 55 times.

Mr.

Mr. *Mellen's* obſervation.

	Temp. app.		
Beginning of the eclipſe,	14^h	14′	5″
Shadow firſt touched *Mare Humorum*,		22	43
Sinus Epidemarum,		23	44
Tycho begins to immerge,		27	7
wholly immerged,		28	34
Grimaldus begins to immerge,		31	41
wholly immerged,		37	51
Lauſbergius begins to immerge,		49	46
Inſula Ventorum begins to immerge,		53	21
Copernicus begins to immerge,	15	3	5
wholly immerged,		14	1
Mare Criſium begins to immerge,		27	51
Tycho begins to emerge,	16	25	51
wholly emerged,		28	21
Mare Criſium wholly emerged,		29	51
End of the eclipſe,		54	36
End of the penumbra,		55	31

Theſe obſervations were made with an achromatic teleſcope, made by *Dolland*, magnifying 40 times.

Mr. *Paine's* obſervation.

Beginning of the eclipſe,	14	14	26
Shadow reaches *Grimaldus*,		32	16
covers *Grimaldus*,		35	59
reaches *Copernicus*,	15	2	54
Grimaldus begins to emerge,		38	23
is wholly emerged,		42	17

O *Tycho*

Tycho begins to emerge,	16h. 26′ 49″
is wholly emerged,	27 52
Mare Crisium wholly emerged,	29 18
End of the eclipse,	53 11
End of the penumbra,	56 11

Mr. *Paine's* observations were made with a reflector, made by *Short*, magnifying 55 times: But this was the first eclipse he had ever observed.

These observations were made at the house of Professor *Williams*. The times were shewn by an excellent astronomical clock, made by *Ellicott*, which was carefully regulated by corresponding altitudes of the sun. The weather was very favourable for observation.

In lunar eclipses the shadow is so imperfectly defined that the beginning and end can seldom be observed without an uncertainty of one minute, and sometimes of two or three minutes. In this eclipse, the circumstances were favourable for observation.

To have a comparative view of the several observations, those phenomena are set down in the following table, which were noted by each observer.

Phases observed by Mess'rs.	Williams,	Winthrop,	Mellen,	Paine.
Beginning of the eclipse,	14h 13 16′	14h 13′ 42″	14 14′ 5″	14h 14′ 26″
Shadow reaches *Tycho*,	28 58	28 5	27 7	
Grimaldus,	31 3	33 27	31 41	32 16
covers *Grimaldus*,	37 51	37 42	37 51	35 59
reaches *Copernicus*,	15 4 10	15 4 6	15 3 5	15 2 54
Tycho begins to emerge,	16 26 27	16 26 5	16 25 51	16 26 49
wholly emerged,	28 19	27 49	28 21	27 52
Mare Crisium wholly emerged,	29 25		29 51	29 18
End of the eclipse,	53 41	53 15	54 36	53 11
End of the penumbra,	55 51	55 45	55 31	56 11

12. Observations

12. Obſervations of a ſolar eclipſe, April 12, 1782, at *Cambridge*.

We had not any compleat obſervation of the beginning of this eclipſe, being interrupted by ſmall fleeting clouds paſſing over the ſun. At $12^{h.}\ 10'\ 45''$, I had a clear view of the ſun, and could not ſee any appearance of the eclipſe. At $12^{h.}\ 11'\ 15''$, I diſcerned a darkneſs upon the weſtern limb, but could not determine whether it was occaſioned by a thin whitiſh cloud which was then paſſing over the ſun, or whether it was the beginning of the eclipſe. At $12^{h.}\ 11'\ 45''$, the cloud left the weſtern limb, and it was apparent that the eclipſe began ſome time before. From theſe circumſtances I think it probable that the beginning of the eclipſe was very near $12^{h.}\ 11'\ 15''$. Mr. *Paine* made the ſame remarks upon the beginning; but noted the darkneſs 5 or 6 ſeconds ſooner than I perceived it.

At the end of the eclipſe we had very good obſervations; the air being clear, and the ſky free from clouds. Theſe obſervations were as follow:

End of the eclipſe

	Temp. app.
By Mr. Williams, with an achromatic teleſcope magnifying 90 times,	$2^{h.}\ 51'\ 30''$
By Mr. Winthrop, with a reflector magnifying 55 times,	2 51 28
By Mr. Mellen, with an achromatic teleſcope magnifying 30 times,	2 51 29
By Mr. Paine, with a reflector magnifying 55 times, - - - -	2 51 15

At $12^{h.}$ I measured the sun's horizontal diameter with an object-glass micrometer, fitted to a reflecting telescope, and by a mean of five observations found it 31′ 54″. At $1^{h.}$ 34′, the obscuration was the greatest: The lucid part of the sun was then 19′ 9″; whence, the greatest eclipse was 4 digits 48′.

13. Observations of a lunar eclipse, September 10, 1783, at *Cambridge*.

The moon rose behind a cloud that lay along the horizon. At $7^{h.}$ 20′, I saw her totally eclipsed. The eastern part was of that dusky copper-colour which is usual in total eclipses: But the western part was so obscure as to be almost invisible, except a circular appearance of light round her limb. At $7^{h.}$ 27″, the clouds broke away, and I had a good observation of the

End of total darkness at $7^{h.}41'\,53''$

In a few minutes the moon was again obscured by clouds: But at $8^{h.}$ 15′, they dispersed and left a very clear sky; after which I made the following observations:

Mare Serenitatis wholly emerged,	8	22	38
Mare Tranquillitatis wholly emerged,		31	3
Mare Crisium begins to appear,		31	33
bisected,		33	38
wholly emerged,		35	43
End of the eclipse,		42	8

These observations were taken with an achromatic telescope magnifying 90 times: But the shadow did not appear to be very distinctly defined.

Mr. Mellen, with a reflecting telescope magnifying 55 times, made the following observations:

End

	Temp. app.
End of total darkness,	$7^{h.}$ 41′ 48″
Langrenus wholly emerged,	8 34 4
End of the eclipse,	42 3

Mr. Paine observed with an achromatic telescope magnifying 30 times. By his observation

The end of total darkness was at	7 42 18
Bright spot in *Mare Vaporum* wholly emerged,	8 14 28
Mare Tranquillitatis wholly emerged,	31 88
End of the eclipse,	42 13

Both these gentlemen observed with me; and the times were taken by the same clock.

The last eleven eclipses were all that could be observed in this part of *America*, from Jan. 1, 1770, to Jan. 1, 1784.

Observations of the eclipses of *Jupiter's satellites*.

1782.		Temp. app.			
June	25,	$9^{h.}$	48′	30″	Em. 2d satellite.
July	2,	12	21	54	Em. 2d satellite.
	3,	12	9	53	Em. 1st satellite.
Aug.	27,	9	6	25	Em. 1st satellite.
	28,	9	3	49	Em. 2d satellite.
Sept.	12,	7	31	29	Em. 1st satellite.

These observations were taken with an achromatic telescope magnifying about 300 times. If they are compared with the calculations in the Nautical Almanac, the *mean* will give $4^{h.}$ 44′ 36″ for the difference of meridians between the Royal Observatory at Greenwich, and the University at Cambridge in America.

Observations

Obſervations of the Tranſits of VENUS and MERCURY over the Sun, in the Years 1769, and 1782.

I. An obſervation of the tranſit of VENUS over the ſun, June 3, 1769, at *Newbury*.

The tranſits of Venus over the ſun are among the moſt uncommon and uſeful phenomena which aſtronomy ever preſents to our view. I had the happineſs of ſeeing that of 1761, at *St. John's*, in *Newfoundland*, attending the late excellent Dr. *Winthrop* in his voyage and obſervations at that place. That of 1769 I obſerved at *Newbury*, at the ſeat of *Triſtram Dalton*, Eſq; a gentleman of *Newbury-Port*.

The teleſcope I uſed was a reflector, made by *Nairne*, magnifying about 55 times; a good inſtrument, but not fitted with a micrometer, or with vertical and horizontal hairs, as I could have wiſhed. The clock was a very good one, and carefully adjuſted to apparent time by correſponding altitudes of the ſun.

The weather for ſeveral days before the tranſit had been dull and rainy; but the third of *June* proved favourable to our wiſhes. The air was uncommonly clear, and the ſky ſerene. About twenty minutes before the tranſit was expected, I began to keep my eye ſteadily fixed on that part of the ſun's limb on which the planet, by calculation, was to enter; an aſſiſtant, counting the clock in the mean time, while another ſtood by to write down the obſervations. Thus prepared, we waited with a kind of agreeable anxiety for the high ſatisfaction of ſeeing Venus on the ſun; a ſatisfaction I had once before enjoyed in viewing the tranſit of 1761, and which I knew muſt end with

with that of 1769. A small irregularity on the sun's limb seemed to denote the approach or first appearance of the planet. At 2$^{h.}$ 30′ 14″ apparent time, I suspected I saw *a small disturbance* on the sun's limb: But the impression was then so small, irregular, and ill defined, that it was not till after several seconds that I was certain the transit was begun. The impression increasing and growing more distinct, I fixed on the time mentioned above as the time of the *external contact*. By observers, in the same state of the atmosphere, with telescopes and eyes equally good, and fixed on that part of the sun on which the planet entered, I imagine this first impression might have been observed to an agreement of five or six seconds.

Soon after Venus had first touched the sun's limb, the whole of her disc became visible: She appeared circular, and was surrounded with a pale glimmering light, not very distinctly defined. From this appearance I concluded it would be impossible to fix upon the precise moment when her limb would be exactly coincident with that of the sun, and therefore determined to wait till there should appear a small thread of light between them. As the *internal contact* drew near, the thread of light began to form, and seemed to dart on each side of the planet for several seconds without being fixed or settled. At 2$^{h.}$ 48′ 44″, with a seeming uncertainty of not more than seven seconds, it became closed and fixed. Venus then appeared wholly within the sun, separated from his limb by a fine stream of light flowing gently round it. This I fixed upon as the *internal contact*. Not having a *micrometer*, or hairs fixed in the reflector, instead of making any further observations, we could only enjoy the pleasure

pleaſure of viewing this curious phenomenon, and ſhewing it to a number of gentlemen who had aſſembled on the occaſion.

In the above account of the *contacts* the duration of the ingreſs or paſſage of Venus over the ſun's limb, is 18′ 30″; near one minute longer than in moſt of the *American obſervations*. By theory it ſhould be 18′ 56″; but as this muſt have been contracted fifteen ſeconds by parallax at the place of obſervation, the apparent duration of the ingreſs would be but 18′ 41″; that is, eleven ſeconds longer than it was made by obſervation. I much doubt whether it was poſſible to diſcern the planet ſo ſoon as eleven ſeconds after the firſt contact, when not a ſecond of its diameter had entered upon the ſun. It ſeems more probable that the *internal contact* was paſt before the thread of light appeared to me to be compleated.

The latitude of the place where this obſervation was made is 42° 47′, north. With regard to it's longitude, the mean of ſix obſervations of the eclipſes of *Jupiter's ſatellites*, give it 1′ 26″ in time eaſt of *Cambridge*.

II. An obſervation of the tranſit of MERCURY over the ſun, November 9, 1769, at *Salem*.

The tranſits of Mercury, though they are not of equal uſe in aſtronomy as thoſe of Venus, are yet of great advantage to perfect the elements of his theory, and to determine the longitude of places on the earth. I had an opportunity to obſerve one of theſe tranſits at the houſe of *Andrew Oliver*, Eſq; at *Salem*.

The

The only instrument we could procure was a reflecting telescope magnifying about 60 times. To ascertain the time I was obliged to make use of a *watch*, which for several days was carefully regulated by the sun's passage over the meridian.—— Taking the minutes from the watch, I counted seconds from one minute to another. And from the pains I took to be exact, I believe the time was well pointed out this way, though such as an Astronomer would by no means chuse.

At $2^{h.}$ 54′ 40″ apparent time, Mercury came on the sun's limb as it were in an instant, in the form of a clear, regular, well-defined black spot. The *internal contact* was equally instantaneous. At $2^{h.}$ 56′ 0″, the thread of light closed to appearance in a moment, without a seeming uncertainty of one second. The sky being perfectly clear and serene, nothing could be better defined than the limbs of Mercury and the sun: But the telescope did not admit of any further observations, either of the diameters of the sun and Mercury, or the least distance of their limbs.

The latitude of *Salem* is 42° 35′ north; and it's longitude is about 1′ 15″ in time east of *Cambridge*.

III. Observations of the transit of MERCURY over the sun, Nov. 12, 1782, at the University in *Cambridge*.

Two gentlemen of the University observed this transit with me: *James Winthrop*, Esq; Librarian, and *Elijah Paine*, A. B.

The instruments which I used in observing this transit, were an achromatic telescope made by *Nairne*, with a magnifying power of 150; a reflecting telescope fitted with an object-

glaſs micremeter made by *Short*, with a magnifying power of 60; and an aſtronomical clock made by *Ellicott*. To regulate the clock with the greateſt accuracy I took a large number of correſponding altitudes of the ſun every day the weather would permit from the beginning of *October*, and found by the moſt careful attention that it kept equal time very exactly: The greateſt error at any time not being more than two ſeconds in twenty-four hours.

On the 12th of November the weather was fair, but the air was not in the moſt favourable ſtate for obſervation. Viewing the ſun with an excellent achromatic teleſcope, I found the ſpots on the diſc well defined; but the limb appeared to have an irregular, tremulous motion. This tremor, or undulation of the ſun's limb, was of different degrees at different times; but it did not wholly ceaſe any part of the day.

At $9^{h.}\ 55'$, I began to keep my eye ſteadily fixed on that part of the ſun's limb on which the planet was to enter; and at $10^{h.}\ 6'\ 0''$ apparent time, I ſaw the firſt appearance of *Mercury*. The impreſſion ſeemed to be ſudden and inſtantaneous, and without any uncertainty as to the time. But the appearance was not like the contact of two circles, or like that of a well-defined black ſpot entering upon the ſun; but rather like a dark oval ſhadow inſtantly entering and mixing with the ſun's limb. Plate I. Fig. VIII. While Mercury was thus entering upon the ſun, no part of it was viſible but that which was within the ſun's diſc. It's figure appeared to be elliptical: The greater axis ſeemed to paſs through the point of contact, and to be about one-third longer than the other. This elliptical appearance of the planet made it impoſſible to determine when the limbs

limbs of the ſun and Mercury exactly coincided. I therefore eſtimated the *internal contact* by the firſt appearance of a ſmall thread of light between them. This took place at 10^h 12′7″. The elliptical appearance was then wholly gone, and Mercury appeared circular, and perfectly well-defined. But the tremulous motion of the ſun's limb was then ſo great, that this obſervation ſeemed to be attended with an uncertainty of eight or ten ſeconds.

When Mercury was wholly within the ſun, I applied myſelf to the micrometer to meaſure the diameters of the ſun and Mercury, and the leaſt diſtance of their limbs. By a mean of eight obſervations taken during the tranſit, I found the ſun's horizontal diameter to be 32′ 21″,85: This was the ſame with the reſult of ſeveral ſimilar obſervations made a little before the tranſit began, and juſt after it ended. To aſcertain the diameter of Mercury, I made twelve obſervations at different times during the tranſit. The greateſt care was taken to have them accurate: And the mean of all the meaſures gave it 9″,247.

In obſerving the leaſt diſtance of the limbs of the ſun and Mercury, I made the following obſervations:

Apparent time.			Leaſt diſt. of the limbs of ☉ & ☿.		
h.	′	″	°	′	″
10	31	53	0	0	12, 33
	30	16			16, 44
	41	22			18, 49
	45	49			22, 00
	47	0			22, 60
	48	32			22, 60
	54	42			18, 49
11	4	20			12, 00

I found considerable difficulty in meaſuring ſuch ſmall diſtances.—But the utmoſt attention was paid to theſe obſervations, as being ſome of the moſt uſeful and important of the whole: And I believe they were taken with as much exactneſs as the inſtrument would admit. Thoſe near the middle I eſteemed the moſt exact.

As Mercury approached the limb of the ſun I again uſed the achromatic teleſcope; and at 11h. 23′ 8″, obſerved *the ſecond internal contact*. Mercury was then perfectly circular and well-defined; and the undulation of the ſun's limb leſs than before. This obſervation did not appear to me to be attended with an uncertainty of more than four or five ſeconds. While Mercury was paſſing the ſun's limb, it's form again appeared elliptical, and the ſame phenomena took place which were noted at the former contacts, but in a much leſs degree. Juſt before the end of the tranſit, the limbs of Mercury and the ſun appeared to be blended and mixed together. At 11h. 29′ 19″, Mercury ſeemed inſtantly to break off, ſeparate, and diſappear. This obſervation I eſteemed the moſt exact of any I had made.*

To

* America was the moſt favourable place for obſerving this tranſit: And the undulation of the ſun's limb ſeems to have been greater, in ſome parts of Europe, than it was here. On ſuch accounts the American obſervations may be of much uſe in the records of aſtronomy. By a letter from M. DE LA LANDE, dated Paris, February 14, 1783, I find they have been viewed in this light by the ROYAL ACADEMY OF SCIENCES AT PARIS. "J'ai recu, Monſieur, avec une extreme ſatisfaction vos lettres "avec les obſervations qui y etoient renfermées. Je les ai preſentée a l' Academie "des Sciences, qui m'a chargé de vous en faire ſes remercimens, et qui les a deſ- "tinées a l' impreſſion. J' ai donné moime au journal des ſavans votre obſervati- "on du paſſage de Mercure, qui m'a fait d' autant plus de plaiſir que notre ob- "ſervation de Paris etoit fort douteuſe a cauſe de l' ondulation des bords du ſoleil."

To ascertain the diameter of the sun by other measures, about 12^{h} I made several observations of his passage over the meridian. These observations were taken with a transit telescope, fitted with three vertical hairs. The times were shewn by a curious *watch*, which distinguishes to a quarter of a second. The mean of ten observations gave $2'\ 16''$, 2, for the time of the sun's passing the meridian. This, reduced to parts of a circle, and multiplied by the co-sine of the sun's declination, gives $32'\ 24''$, 20, for the sun's apparent diameter.

Mr. *Winthrop's* observation.

The telescope Mr. Winthrop used was a large reflector, made by *Short*. It's apperture is eight inches, and it's focal distance forty-eight. It has four magnifying powers—120, 260, 380, and 500. The magnifying power Mr. Winthrop used was 260. With this he observed

	Temp. app.
The first external contact at	10^{h} 6' 31"
The first internal contact at	12 13
The second internal contact at	11 23 5
The second external contact at	29 10

With regard to these observations it should be noted, that the times in both our observations were taken by the same clock; but we observed at different parts of the house, and without any kind of communication together. The observations of the first external contact differ thirty-one seconds. Those of the first internal contact are within six seconds. Those of the second internal contact differ but three seconds: And in those of the last external contact there is no difference at all. The observation

ſervation of the laſt external contact Mr. Winthrop ſuppoſes was attended with the greateſt certainty: And he noted thoſe optical phenomena which have been mentioned.

Mr. *Paine's* obſervation.

Mr. Paine uſed a reflector made by *Nairne*, magnifying 50 times. This teleſcope is fitted with vertical and horizontal hairs; and is ſo made that theſe hairs may be adjuſted to any ſituation; to obſerve differences of altitude and azimuth, or thoſe of right aſcenſion and declination.

By his obſervation, the firſt external contact was at $10^{h}\cdot 7' 7''$.
The internal contact was not accurately noted.

During the tranſit, he made the following obſervations of the difference of right aſcenſion between the limbs of the ſun and Mercury: The hairs in the focus of the reflector being ſo placed that the upper limb of the ſun appeared to move along one hair, and of conſequence, the other was perpendicular to the Equator.

	Temp. app.	
1.		
Sun's preceding limb at the hair,	$10^{h}\cdot 25'$	$50''$
Mercury's center at the ſame,	27	35
Sun's ſucceeding limb at the ſame,	28	6
2.		
Sun's preceding limb at the hair,	32	49
Mercury's center at the ſame,	34	32d
Sun's ſucceeding limb at the ſame,	35	6
3.		
Sun's preceding limb at the hair,	48	36
Mercury's center at the ſame,	50	13
Sun's ſucceeding limb at the ſame,	50	53

Sun's

4.	Temp. app.
Sun's preceding limb at the hair,	11h. 1′ 58″
Mercury's center at the fame,	3 30
Sun's fucceeding limb at the fame,	4 15
5.	
Sun's preceding limb at the hair,	5 41
Mercury's center at the fame,	7 11
Sun's fucceeding limb at the fame,	7 57
6.	
Sun's preceding limb at the hair,	13 59
Mercury's center at the fame,	15 26
Sun's fucceeding limb at the fame,	16 15
Laft internal contact,	22 5
Laft external contact,	28 6

In refpect to Mr. *Paine's* obfervations of the contacts we may remark, that they appear to have been carefully made, notwithftanding they differ fo much from thofe made with much larger telefcopes. The difference in the obfervations evidently arofe from the difference of telefcopes. Mercury was feen with an achromatic magnifying 150 times, 1′ 7″ fooner at the firft contact, and 1′ 13″ later at the laft contact, than it was with this fmall reflector. The mean of thefe, 1′ 10″, may be taken as the difference which arofe from the difference of telefcopes in obferving fo fmall an object as Mercury, in fuch a ftate of the atmofphere. Allowance being made for this difference, Mr. Paine's obfervations of the contact will be found to agree as well with the other obfervations of the contact, as they do with each other. The obfervations of the differences of right afcenfion would be very little affected by this caufe, and therefore do not want any correction.

From

From these observations it will be easy to compute all the circumstances of this transit, and the principal elements of the theory of Mercury.

Thus, Plate I. Fig. IX. let the circle ÆAQ represent the sun; NS the ecliptic; ÆQ a parallel to the equator; VA the apparent path of Mercury; NE part of Mercury's orbit. SA is a perpendicular to the equator; SE a perpendicular to the ecliptic; and SM a perpendicular to Mercury's visible way. The middle of the transit will be when Mercury arrives at the point M; the ecliptical conjunction at E; and the conjunction in right ascension at A: And N will represent the place of Mercury's ascending node.

The middle of the transit is given by the observations of the contacts. This,

	Temp. app.
By my observations of the external contacts, was at	10h 47′ 39″,5
By those of the internal contacts,	10 47 37, 5
My Mr. Winthrop's obs. of the internal contacts,	10 47 39
The mean of which may be assumed as most exact,	10 47 38,66

The visible conjunction of the sun and Mercury in right ascension, may be deduced from Mr. Paine's observations of their differences, &c. The result of these observations, as I have deduced them from calculation, are as follow:

Obs.	App. Time.	Difference R. A. of ☉'s center, and ☿ in Time.	Diff. R. A. in Parts of a Circle reduced to the Equator.	Time of Conjunction of ☉ and ☿ in Right Ascension.
1	10h 27′ 35″	37″	8′ 48″, 2	12h 5′ 55″
2	34 32d	34, 5	8 12, 3	12 5 15
3	50 13	28, 5	6 46, 8	12 5 59
4	11 3 30	23, 5	5 35, 4	12 5 58
5	7 11	22	5 14, 0	12 5 40
6	15 26	19	4 31, 3	12 5 57
			Mean,	12 5 57, 33

The

The apparent diameters of the ſun and Mercury are alſo determined by obſervation.

By the micrometer meaſures, Mercury's diam. was	9″,247
The diam. of the ſun by the microm. meaſures was	32′ 21, 85
By the time of it's paſſing the meridian,	32 24, 20
The mean of which may be taken as moſt exact,	32 22, 96

The leaſt diſtance of centers is alſo had from obſervation.

By the micrometer meaſures this was	15 43, 70

To examine the obſervations made by the micrometer, I computed by trigonometry what the leaſt diſtance of centers would be by calculation from the obſervations of the contacts. The reſult gives the leaſt diſtance

By my obſervations of the external contacts,	15 44, 1
By thoſe of the internal contacts,	15 43, 5
By Mr. Winthrop's obſerv. of the internal contacts,	15 43, 6
The mean is the ſame as by the micrometer,	15 43, 73

From the obſervations of the diameters and leaſt diſtance of centers, we may compute the length of the apparent tranſit-line, and Mercury's viſible horary motion from the ſun. In the right-angled triangle SM*m*, we have SM the leaſt diſtance of centers, and S*m* the ſum of ſemi-diameters. Multiply the the ſum of S*m* and SM by their difference, the ſquare root of the product will be the length of M*m*. By ſuch a calculation (all the circumſtances of the obſervations being taken into conſideration) the length of the tranſit-line, eſtimated

By the external contacts, is	496″,2
By the internal contacts, is	423, 0

And hence,

By proportion, ☿'s viſ. horary mot. from the ſun was	5′ 57, 33

From

From these *data* we may determine the angle of Mercury's visible way with the ecliptic, the geocentric latitude, and the time of the ecliptical conjunction. In the right-angled triangle SMA, SM is given, and MA is known by the visible horary motion of Mercury from the sun. Hence, we can find SA, and the angle MSA 26° 13′ 28″. ESA is the angle made by that parallel to the Equator which passes through the sun's center at the ecliptical conjunction, and the ecliptic; and is equal to the sun's declination at that time, 17° 52′ 55″. Subtract this angle from MSA, and we have the angle MSE, the angle of Mercury's visible way with the ecliptic, 8° 20′ 33″. Again, in the right-angled triangle SME, we have SM, and the angle MSE; from which we can find SE and ME. The former is the geocentric latitude, and the latter is the difference between the middle of the transit and the ecliptical conjunction. By such a calculation corrected by parallax, at the ecliptical conjunction the geocentric latitude of Mercury was 15′ 56″, 8: And the time of ecliptical conjunction, Nov. 12d. 11h. 10′ 58″.

In the above calculation, the parallax of Mercury from the sun at the ecliptical conjunction, is supposed to be 3″, 09 in latitude, and 1″, 50 in longitude.

The geocentric latitude and the angle of Mercury's visible way with the ecliptic being known, we can also determine the place of Mercury's node, and the inclination of his orbit to the plane of the ecliptic. If we assume Mercury's distance from the earth to be 67683, and his distance from the sun 31198, his heliocentric latitude at the ecliptical conjunction will be 34′ 36″; his horary motion in the ecliptic, 15′ 18″, 21; and his horary motion in the ecliptic from the sun, 12′ 47″, 01.

Then

Then, in the the right-angled spherical triangle VSE, SE and the angle VES are known; from which we can find the side SV, $3^{\circ}\ 55'\ 33''$. If this be increased in the ratio of $12'\ 47'',01$ to $15'\ 18'',21$, we shall have the side SN, Mercury's distance from the node, $4^{\circ}\ 41'\ 59''$. Subtracting this from $7^{s}\ 20^{\circ}\ 26'\ 36''$ the sun's place at the time of ecliptical conjunction, (by Mayer's tables) we shall have the place of Mercury's ascending node in ♉, $15^{\circ}\ 44'\ 37''$.

Again, in the right-angled spherical triangle SNE, the sides SE and SN are given: From these we can find the angle SNE the inclination of Mercury's orbit to the plane of the ecliptic, $7^{\circ}\ 0'\ 13''$.

In computing the place of Mercury's node and the inclination of his orbit, the calculation chiefly depends on the angle of Mercury's visible way with the ecliptic. This may be computed from the observations of the *contacts*. But a very small error in those observations, will produce a very considerable one in the deductions. It was therefore thought best to deduce it from the observations of *right ascension*, which are equally convenient, and more numerous.

V. *Some select Astronomical Observations made at* Chelsea, *Latitude* 42° 25′, *and* 26″ *in Time East of the University at* Cambridge. *By the Rev.* PHILLIPS PAYSON, *F. A. A.*

THE use of astronomical observations, to promote the purposes of navagation and geography, must be evident to every person that has paid any proper attention to the subject. By comparing observations made in different places, it is well known, special advantages accrue; and by transmiting those of one age down to another, affords astronomers, in future time, great helps for improvement: And no doubt but improvements will be made in this divine science to the end of time.

The extensive territories of the United States of *America*, are a foundation in nature for a vast empire.—The geography of its interior parts, though of great importance, is, at present, but little better than conjectural: To perfect which, and fix the interesting boundaries and lines, the best, and indeed the only proper method is, that of astronomical observations, which, it is probable, the Supreme Council of *America* will soon adopt, now the glorious revolution is so happily compleated. To promote such observations, both at noted head-lands upon the sea-coast, and at distant places in the interior country, highly merits the attention of this Academy: For though they should not at first be made with such accuracy as modern astronomy can boast of, they will prove great helps for future improvements.

The mode of observation, to determine the latitude of a place, is of very easy acquisition: Nor is that difficult which settles its longitude, if a person can be furnished with a good time-piece, *Hadley's*

Hadley's quadrant, and a tolerable telefcope. The eclipfes of Jupiter's fatellites being fo frequent, and of fuch eafy obfervation, they prove very favourable phenomena for this purpofe.

But where great accuracy is required, a folar eclipfe or an occultation of a ftar by the dark fide of the moon, are to be prefered.

Several places in this and fome other ftates in the union, have been determined in refpect to each other, with much precifion, from obfervations of late years. Such as fhall be made in future, may correct fome errors of the prefent.

The following obfervations were made with much care and attention. The clock was an excellant good one, regulated by equal altitudes of the fun taken by reflection with *Hadley's* quadrant: It was counted by a perfon much ufed to the thing; and in all of them, fpecial care was taken in adjufting the equation of equal altitudes for the decreafe or increafe of the fun's declination.

The glafs ufed, is a reflecting telefcope, made by *Nairne*, better than 2 feet in length, and magnifying about 55 times. In a clear air, it fhows the fatellites of Jupiter to be nearly of the bignefs of ftars of the firft magnitude.

Emerfions of Jupiter's fatellites in the year 1779.

1ft. Sattelite.	App. Time.	2d. Satellite.	App. Time.
April 22,	$10^h\ 37'\ 3''$	May 29,	$8^h\ 58'\ 00''$
May 8,	8 57 19	June 30,	8 39 15
15,	10 52 7	3d. Satellite.	
June 23,	9 16 40	May 16,	8 54 20
		23,	12 52 40
		June 28,	8 36 1

Obfervations

Observation of a solar eclipse, June 24, 1778.

	App. Time.
Beginning, A. M.	$9^{h.}$ 6′ 42″
Middle,	10 21 55
End exact,	11 38 23

Observation of a lunar eclipse, May 29, 1779.

Immersion	☽'s S. E. limb,	10 15 44
Ditto	☽'s N. W. limb,	11 31 16
Emersion	☽'s N. E. limb,	12 50 42
Ditto	☽'s S. W. limb,	14 5 55

Observation of a solar eclipse, October 27, 1780.

Beginning,	11 00 58
Immersion of four spots, nearly in a line, just above the ☉'s center. Spot 1st. Plate II. Fig. I.	11 33 6
2d.	11 34 15
3d.	11 35 6
4th.	11 36 18
Immersion of a large spot nearly in the ☉'s center.	
Beginning,	11 36 18
Spot covered, i. e. end,	11 37 20
Emersion of the four spots above the ☉'s center.	
Spot 1st.	12 53 3
2d.	12 54 23
3d.	12 55 5
4th.	12 56 9
Emersion of the large spot near the ☉'s center.	
Beginning,	12 56 44
Compleated,	12 57 45
Eclipse ended,	1 40 37
Duration,	2 39 39

At

At $11^{h.}$ $15'$, mercury in the thermometer stood at 59°.—It sank gradually; and at $12^{h.}$ $30'$, stood at 51°.—Then gradually rose to 59°, at $1^{h.}$ $15'$. A little before $12^{h.}$, there appeared a large halo, or circle, around the sun, and continued for some time.

Observation of a lunar eclipse, November 11, 1780.

	App. Time.
Beginning,	$10^{h.}27'\ 15''$
End,	1 18 50
Duration,	2 51 35

Observation of a solar eclipse, April 12, 1782.

Beginning not observed, the face of the sun being covered with clouds.

Correct app. time of the end of the eclipse, P. M. 2 52 21

Observation of a transit of Mercury over the sun, November 12, 1782.

First ext. contact observed a few seconds too late,	10 7 41
First internal ditto,	10 12 36
Second internal ditto,	11 23 31
Second external ditto,	11 28 58
Duration of the transit,	1 21 17

VI. *Observation of the Transit of Mercury over the Sun, November* 12, 1782, *at* Ipswich. *By the Reverend* MANASSEH CUTLER, *F. A. A.*

CORRESPONDING altitudes of the sun were taken with a sextant, made by *Nairne* and *Blunt*, for regulating my clock, before and after the transit, viz.—On the 7th of Nov. were taken eight set of the upper, and nine set of the lower limb :—On the 8th, twelve set of the upper, and ten set of the lower limb :—On the day of the transit, eighteen set of the upper, and fourteen set of the lower limb, taken at different intervals :—On the 14th, nine set of the upper, and eleven set of the lower limb :—On the 15th, six set of the upper, and eight of the lower limb ;—and on the 18th, seven set of the upper, and nine set of the lower limb. The equation of declination was added to each set of altitudes. By the result, found my clock went with great uniformity, but gained 7″ 33‴ in twenty-four hours.

The day of the transit was clear and pleasant, with very little wind. My observation was made with a reflecting telescope, magnifying 45 times.

By an unfortunate accident, I failed of seeing the first external contact. At the time of the first internal contact, the sun's limb was exceedingly well-defined ; but at the second internal and external contacts, the undulation of the limb was considerable.

	App. Time.
First internal contact,	$10^h\ 13'\ 37''$
Second ditto ditto,	11 24 15
Second external ditto,	11 30 20

VII. *A Memoir, containing Obſervations of a Solar Eclipſe, October* 27, 1780, *made at* Beverly: *Alſo of a Lunar Eclipſe, March* 29, 1782,—*of a Solar Eclipſe, April* 12, *and of the Tranſit of Mercury over the Sun's Diſc, November* 12, *the ſame Year, made at the Preſident's Houſe in* Cambridge. *By the Rev.* JOSEPH WILLARD, *Preſident of the Univerſity.*

Obſervations of a ſolar eclipſe, October 27, 1780, at *Beverly*.

I ATTENDED to my clock for a number of days before the eclipſe, but more particularly on the 25th, 26th and 27th. On each of thoſe days, the ſtate of the atmoſphere was favourable for taking correſponding altitudes of the ſun. I took a number of double altitudes, both of his upper and lower limb, in the forenoon and afternoon, with *Hadley's* octant, by reflection from a bowl of very clear oil of tar, which was of ſuch a conſiſtence as to prevent undulation from the air, and in which, the ſolar image was extremely well defined. I noted the times by the clock, when the limbs of the two images of the ſun juſt came into contact. The conjunction of the centers I did not attempt to take, becauſe it cannot be determined with a certainty equal to the contact of the limbs.

The equation for the change of the ſun's declination, during the half interval between the forenoon and afternoon obſervations, was conſtantly applied.

Obſervations of correſponding double altitudes of the ſun, October 25.

	Foren. obſ.	Aftern. obſ.	Intervals.	½ Intervals.	Noon per clock nearly.
Sun's upper limb.	$8^h\ 35'\ 2''$	$3^h\ 22'\ 46''$	$6^h\ 47'\ 44''$	$3^h\ 23'\ 52''$	$11^h\ 58'\ 54''$
	8 39 40	3 18 8	6 38 28	3 19 14	11 58 54
	8 42 0	3 15 47	6 33 47	3 16 53½	11 58 53½
	8 44 23	3 13 25	6 29 2	3 14 31	11 58 54

R

Sun's

	Foren. obs.	Aftern. obs.	Intervals.	½ Intervals.	Noon per clock nearly.
Sun's lower limb.	$8^h 50' 46''$	$3^h\ 7'\ 5''$	$6^h 16' 19''$	$3^h\ 8'\ 9\frac{1}{2}''$	$11^h 58' 55\frac{1}{2}''$
	8 55 32	3 2 16	6 6 44	3 3 22	11 58 54
	9 0 24	2 57 30	5 57 6	2 58 33	11 58 57
	9 2 48	2 55 8	5 52 20	2 56 10	11 58 58

Time of noon nearly by the clock, by a mean of the above eight obs.	11 58 55
Equation for change of declination in the ½ interval,	+ 16
Exact time by the clock, when ☉'s center passed the meridian,	11 59 11
Hence, the clock too slow for apparent time at noon,	49

In like manner observations were made on the 26th and 27th, the result of which it is sufficient to put down.

On the 26th,

When the sun's center passed the meridian, it was, by the clock, allowing for the equation,	$11^h\ 58'\ 16''$
Hence, the clock too slow for app. time at noon,	1 45

On the 27th,

When the sun's center passed the meridian, it was, by the clock,	11 57 18
Hence, the clock too slow for apparent time at noon, on the day of the eclipse,	2 42
Loss of the clock, respecting apparent time, between the noon of the 25th and 26th,	56
Ditto, 26th and 27th,	57

In the morning of the 27th, the Reverend Mr. *Cutler*, of *Ipswich*, and the Reverend Mr. *Prince*, of *Salem*, favoured me with their company, to observe the eclipse with me. Mr. *Cutler* and I were each furnished with a reflecting telescope, made by *Mann*, of *London*. The magnifying power of Mr. *Cutler's*, was 34, and that of mine, 45 times. Mr. *Prince's* telescope was an achromatic refractor of 3 feet. It's original magnifying power was 16½; but he increased it to 43 times, by taking out the third glass of the sliding-tube, and adding another eye-glass

of

of about an inch focus. We determined the magnifying power of our telefcopes by *Hawkfbee's* method.

We fat down to our telefcopes about ten minutes before eleven o'clock, in a garden adjoining the room where the clock was fixed, and were fo fituated, that we could all very diftinctly hear the perfon who counted the clock. Before we began to obferve, we agreed that each one fhould note his times of obfervation, without fpeaking to the others, that all might determine for themfelves, and no one might be in danger of being difconcerted.

We had a favourable time for obferving the beginning and end of the eclipfe. The immerfions and emerfions of a number of the folar fpots were attended to by us; the fituations of which, upon the difc, we determined as near as we could, a little while before we fat down to our telefcopes. They then appeared to us as in Plate II. Fig. II. Mr. *Prince* had fixed parallel hairs in his refractor, dividing the fun's difc into four equal parts, horizontally. Thefe hairs, together with a vertical one in the center, affifted us much in fettling the places of the fpots.

As we had no micrometer to meafure the magnitude of the eclipfe, we determined it by Dr. *Wallis's* method, publifhed in *Whifton's* Aftronomical Lectures, p. 188, 189. The eclipfed parts of the fun, marked at the time of the greateft obfcuration, we afterwards meafured upon a diagonal fcale drawn for the purpofe, by which we could determine to the fiftieth part of a digit.

At the middle of the eclipfe, and for fome time before and after it, there was a very great chilnefs in the air, and fo much dew fell, that the papers we ufed abroad became quite damp.

 The

The following are our obſervations of this eclipſe, adjuſted to apparent time.

	Mr. *Willard.*	Mr. *Cutler.*	Mr. *Prince.*
Beginning of the eclipſe,	11h 1′ 48″	11h 1′ 42″	11h 1′ 46″
Immerſions of the weſtern edges of ſolar ſpots.			
No. 1, of the weſtern ſpots,	11 22 31	11 22 28	11 22 41
No. 1, of the north-eaſtern ſpots,	11 33 31	11 33 23	11 33 25
No. 3, of ditto,	11 35 21	11 35 22	11 35 23
A large ſpot near the center,	11 36 56	11 36 54	11 36 57
A ſouth-eaſtern ſpot neareſt the vert. diam.		12 11 34	12 11 37
Emerſions of the eaſtern edges of ſolar ſpots.			
No. 2, of the weſtern ſpots,		12 31 55	12 31 56
No. 1, of the north-eaſtern ſpots,	12 53 50	12 53 47	12 54 4
No. 2, of ditto,	12 54 53	12 54 57	12 55 0
No. 3, of ditto,	12 55 36	12 55 36	12 55 41
No. 4, of ditto,	12 56 32	12 56 31	12 56 38
The large ſpot near the center,	12 58 6	12 58 4	12 58 14
The end of the eclipſe,	1 41 26	1 41 23	1 41 29
The duration,	2 39 38	2 39 41	2 39 43

By our obſervation, the greateſt obſcuration was at about $12^h 21'$, apparent time, when the parts eclipſed were 11 dig. 24.′

The clock's rate of going was the ſame for ſeveral days following the 27th, as it had been for the two days preceding.

N. B. 1. By twenty-ſeven double altitudes of the ſun, when upon the meridian, taken with a *Hadley's* octant, very accurately conſtructed, I have found the latitude of the houſe, where the foregoing obſervations were made, 42° 36′ N.——The houſe ſtands facing the middle of the training-field, (ſo called) in the firſt pariſh in *Beverly*.

N. B. 2. By calculations from the obſervations of the foregoing eclipſe made at *Beverly*, and thoſe made at *Chelſea*, I find the difference of meridians to be 45″ in time; which, added to 26″, the difference between *Chelſea* and *Cambridge*, makes 1′ 11″ for the difference between *Cambridge* and *Beverly*. The difference between *Beverly* and *Penobſcot*, where Profeſſor *Williams* and company made their obſervations, I find, in the ſame way,

way, to be 8′ 4″, which makes the difference between *Cambridge* and *Penobſcot* 9′ 15″. The difference between *Beverly* and *Providence*, by deductions from the obſervations, is 2′ 18″, which gives 1′ 7″ between *Cambridge* and *Providence*.

Obſervations of a lunar eclipſe, March 29, 1782, made at the Preſident's houſe in *Cambridge*.

The going of my clock was aſcertained, for the obſerving of this eclipſe, in the ſame manner as for the foregoing one of October 27, 1780.

Mr. *Caleb Gannett* obſerved the eclipſe with me. The teleſcope I made uſe of was an achromatic refractor, with a magnifying power of 90. Mr. *Gannett* made uſe of a reflecting teleſcope, of about the ſame magnifying power. We had, upon the whole, a pretty favourable time; though the earth's ſhadow, at the moon, did not appear ſo well defined as we could have wiſhed.*

The obſervations follow.

		Apparent Time.	
		By Pref. *Willard.*	By Mr. *Gannett.*
Beginning of the eclipſe,		$2^h\ 14'\ 7''$	$2^h\ 14'\ 0''$ A. M.
Shadow touches	*Harpalus*,	22 51	22 57
	Tycho,	27 21	27 10
covers	*Tycho*,	29 16	29 4
touches	*Mare Criſium*,	3 28 49	3 28 10
leaves	*Mare Criſium*,	4 28 36	4 28 17
leaves	*Mare Tranquilitatis*,	33 40	34 7
End of the eclipſe,		4 53 50	4 53 33

Obſervations

* In obſervations of different lunar eclipſes, when the ſtate of the atmoſphere, as far as the eye could determine, has been the ſame, the earth's ſhadow has appeared much better defined in one, than in another.

Observations of a solar eclipse, April 12, 1782, made at the President's house.

The going of my clock was ascertained in the same manner as at the time of the lunar eclipse, in March.

Mr. *Caleb Gannett* and Mr. *William King* observed the eclipse with me. Mr. *Gannett* and I had the same telescopes that we used for observing the lunar eclipse. Mr. *King* was furnished with a good reflecting telescope, the magnifying power of which was about 40. At the beginning of the eclipse the clouds were troublesome; so that the entrance of the moon upon the sun's limb was not seen by us, or by any of the observers in *Cambridge*. But the clouds dispersed soon afterwards, and the atmosphere became perfectly clear; so that we had a very favourable time for observing the end of the eclipse, which was,

	Apparent Time.
By President *Willard*, at	$2^h\ 51'\ 41''$ P.M.
Mr. *Gannett*,	2 51 27
Mr. *King*,	2 51 41

As we were not furnished with a micrometer, no other observations, of any consequence, were made by us upon this eclipse.

Observations of the transit of Mercury over the sun's disc, November 12, 1782, made at the President's house.

The going of my clock was determined, for this phenomenon, as for the eclipses, in the spring.

Mr. *Caleb Gannett* observed with me. We were furnished with the same telescopes that we made use of for observing the eclipses. Our observations were as follow.

	Apparent Time.			
	1st ext. cont.	1st int. cont.	2d int. cont.	2d ext. cont.
By Pres. *Willard*,	$10^h\ 6'\ 27''$	$10^h\ 12'\ 37''$	$11^h\ 23'\ 2''$	$11^h\ 29'\ 32''$ A.M.
By Mr. *Gannett*,		10 12 45	11 23 36	11 29 29
Mean,		10 12 41	11 23 19	11 29 $30\frac{1}{2}$

	—10h 12′ 41″	—10h 6′ 27″
Duration of the transit,	internal 1 10 38	ext. 1 23 3½

The state of the atmosphere was unfavourable, during the transit. The limb of the sun appeared serrated; so that it was difficult to determine the contacts, with that precision which could be wished.

At the time of the first internal contact, and for some minutes after, the limb of ☿, next to the sun's eastern limb, had an oval appearance; and his limb, next to the western limb of the sun, put on the same appearance, a few minutes before, and at the time of the second internal contact.

For ☿'s horizontal parallax.

☿'s distance from the earth 67681 : the sun's distance from the earth 98879 :: the sun's horizontal parallax 8″, 55 : ☿'s horizontal parallax 12″, 49. Therefore, ☿'s horizontal parallax from the sun is 3″, 94.

Elements for calculating ☿'s parallax from the sun in latitude and longitude, at *Cambridge*, at the first external contact, November 12, 1782, at 10h. 6′ 27″, A. M. apparent time.

The sun's longitude,*	7s. 20° 23′ 53″, 304
Mercury's geocentric longitude,	7 20 30 12, 078
Mercury's geocentric latitude, north,	14 55, 754
The sun's right ascension,	227 57 5
The right ascension of the mid-heaven,	199 33 50
Angle answering to *p*PZ in Plate I. Fig. I.	70 26 10
The sun's horary motion,	2 31, 2
Mercury's geo. hor. mot. in long. in the ecliptic retro.	3 22, 32

Mercury's

* The elements of the sun are calculated from *Mayer's*, and those of Mercury from M. de la *Lande's* tables.

Mercury's geo. hor. mot. from the sun in the eclipitc,	5′ 53″, 52
Mercury's geo. hor. motion in latitude increasing,	51, 96
The sun's semi-diameter,	16 12, 2
Mercury's semi-diameter,	5, 1
Mercury's horizontal parallax from the sun,	3, 94
The obliquity of the ecliptic,	23°28 12
The lat. of *Cambridge* reduced to the center,	42 8 37

Hence,

The altitude of the nonagesimal degree,	44 24 32
The longitude of the nonagesimal degree,	5s. 26 45 44
Mercury's parallax in latitude from the sun,	2, 807
Mercury's parallax in longitude from the sun,	2, 224

At the second external contact, at 11h, 29′ 30½″, A. M. apparent time; by calculation,

Mercury's parallax in latitude from the sun,	3, 169
Mercury's parallax in longitude from the sun,	1, 280

The longitude of the nonagesimal degree, at the time both of the first and second external contact, being less than the longitude of Mercury, the parallax in longitude is to be added to Mercury's longitude, in each, to give the visible; and as Mercury's motion in transits is retrogade, and the parallax at the time of the second external contact was greater than at the time of the first, the length of the visible transit-line was greater than the true, by the difference of the parallaxes.

The true latitude, at each contact, was diminished by the parallax in latitude; and as the geocentric latitude was increasing, and the parallax, at the time of the second external contact, greater than at the time of the first, the visible motion in latitude was less than the true, by the difference of the parallaxes.

S's

☿'s parallax in longitude from ⊙, 1st ext. cont.		2'',224
Ditto,	2d,	1, 280
Difference,		0, 944
☿'s parallax in latitude from ⊙,	1st,	2, 807
Ditto,	2d,	3, 169
Difference,		0, 362
☿'s true mot. on ⊙'s disc in $1^{h.}$ 23' 3½'' reduc. to the ecl.		8' 9, 376
Difference of parallaxes in longitude,		+ 0, 944
Length of the vis. transit-line reduced to the ecliptic,		8 10, 320
		= 490'', 32
☿'s true motion in latitude in $1^{h.}$ 23' 3½'',		1 11, 928
Difference of parallaxes in latitude,		— 0, 362
Visible motion in latitude,		1 11, 566
		= 71'', 566

For the angle of Mercury's visible way with the sun in the ecliptic; the error of the tables in latitude; and the time of the ecliptic conjunction of ⊙'s and ☿'s centers, deduced from the times of the external contacts.

In Plate II. Fig. III. let EDK represent half of the sun's disc; the diameter E⊙K a portion of the ecliptic, or rather a parallel to it;* ☿U a parallel = 490'', 32 Mercury's visible motion upon the sun's disc, reduced to the ecliptic; UM Mercury's visible motion in geocentric latitude, during the time between the two external contacts; consequently, M☿U, the angle required, and ☿M the visible transit-line; the point ⊙ the sun's center, at the apparent time of the visible conjunction of centers; ⊙N, perpendicular to ☿M, the visible least distance of centers; ⊙D perpendicular to the ecliptic, the visible distance

S

* The distance from the ecliptic being equal to the sun's parallax in latitude.

tance of centers, at the time of the visible ecliptic conjunction; ☿☉ and M☉ the distance of centers, at the time of the external contacts, = the sum of the semi-diameter of the sun and of Mercury = 977″, 3; C☿ the visible difference of latitude of the centers, at the time of the first external contact; LM the visible difference, at the time of the second; C☉ = ☿F the visible difference of longitude of the centers, at the time of the first; and ☉L at the time of the second external contact.

For M☿U, the angle of Mercury's visible way.

☿U 490″, 32 : UM 71″, 566 :: Radius : Tangent angle M☿U 8° 18′ 15″.

For ☿M, the visible transit line.

Sine M☿U 8° 18′ 15″ : UM 71″, 566 :: Radius : ☿M 495″, 512. As ☿☉ and M☉ are equal, the perpendicular ☉N bisects ☿M; therefore, ☿N and NM are 247″, 756 each.

For angle ☿☉N.

☉☿ 977″, 3 : Radius :: ☿N 247″, 756 : Sine angle ☿☉N 14° 41′ 7″. Add angle N☉D = M☿U 8° 18′ 15″, the sum is = angle ☿☉D = ☿☉F = ☉☿C = 22° 59′ 22″; the complement of which is = angle ☿☉C = 67° 0′ 38″.

For side C☿ = Mercury's visible latitude from sun, at the first external contact.

Radius : ☉☿ 977″, 3 :: Sine angle ☿☉C 67° 0′ 38″ : C☿ 899″, 68 = 14′ 59″, 68; to which add the parallax in latitude 2″, 807, and the sum 15′ 2″, 487 is Mercury's true latitude by observation, at the time of the first external contact.

For side C☉, the visible difference of longitude of the centers of the sun and Mercury, at the time of the first external contact.

Radius : ☉☿ 977, 3 :: Sine angle ☉☿C 22° 59′ 22″ : C☉ = ☿F 381″, 696; from which subtract 2″, 224, Mercury's parallax

parallax in longitude from the ſun, becauſe his viſible longitude was greater than the true, and the remainder, 379″, 472, will be the true difference of longitude.

For the apparent time of the true ecliptic conjunction, and Mercury's true latitude by obſervation.

Mercury's ecliptic horary motion upon ☉'s diſc 353″, 52 : $1^{h.}$ = 3600″ :: the true difference of longitude 379″, 472 : $3864\frac{1}{4}$″, the ſpace of time from the firſt external contact to the ecliptic conjunction, = $1^{h.}$ 4′ $24\frac{1}{4}$″ ; which, added to $10^{h.}$ 6′ 27″, gives $11^{h.}$ 10′ $51\frac{1}{4}$″, for the apparent time of the true ecliptic conjunction.

In $1^{h.}$ 4′ $24\frac{1}{4}$″, Mercury's geocentric latitude was encreaſed 55″, 774 ; which, added to 15′ 2″, 487, his latitude at the firſt external contact, makes 15′ 58″, 261, for Mercury's true latitude by obſervation, at the time of the true ecliptic conjunction, by the external contacts.

Deductions from the internal contacts.

Let the references be to Plate II. Fig. III. the lines ☉☿ and ☉M being ſuppoſed = the difference of the ſemi-diameters of the ſun and Mercury = 967″, 1 ; and, conſequently, the tranſit-line wholly within the ſun's diſc.

☿'s parallax in longitude from ☉,	1ſt int. cont.	2″, 158
Ditto,	2d,	1, 355
Difference,		0, 803
☿'s parallax in latitude from ☉,	1ſt,	2, 837
Ditto,	2d,	3, 145
Difference,		0, 308

☿'s true mot. on ☉'s disc in $1^{h.}$ 10′ 38″ reduc. to the ecli.	6′ 56″, 171
Difference of parallaxes in longitude,	+ 0, 803
Length of the vis. transit-line reduced to the ecliptic,	6 56, 974
	= 416, 974
☿'s true motion in latitude in $1^{h.}$ 10′ 38″,	1 1, 168
Difference of parallaxes in latitude,	— 308
Visible motion in latitude,	1 0, 86
	= 60, 86

Hence,

M☿U, the angle of Mercury's visible way 8° 18′ 15″; — ☿M, the visible transit-line, 421″, 392;—angle ☿☉N 12° 35′ 1″, consequently, ☿☉D = ☿☉F = ☉☿C 20° 53′ 16″, and angle ☿☉C 69° 6′ 44″;—side C☿, Mercury's visible latitude from the sun, at the time of the first internal contact, 903″, 543 = 15′ 3″, 543; which, added to the parallax in latitude from the sun, 2″, 837, gives 15′ 6″, 38, for Mercury's true latitude by observation, at the time of the first internal contact; —the side C☉, the visible difference of longitude of the centers of the sun and Mercury, 344″, 809; which, lessened by the parallax in longitude from the sun, 2″, 158 gives 342″, 651 for the true difference of longitude; which, converted into time, gives 58′ 9½″. This added to $10^{h.}$ 12′41″, A. M. gives $11^{h.}$ 10′ 50½″, for the apparent time of the true ecliptic conjunction.

In 58′ 9½″, Mercury's geocentric latitude was increased 50″ 365; which, added to 15′ 6″, 38, his latitude at the first internal contact, gives 15′ 56″, 745, for Mercury's true latitude by observation, at the time of the true ecliptic conjunction, by the internal contacts.

The

The apparent time of the true ecliptic conjunction, by the external contacts, being $11^{h.}\ 10'\ 51\frac{1}{4}''$, and by the internal ones $11^{h.}\ 10'\ 50\frac{1}{2}''$, let us call the time $11^{h.}\ 10'\ 51''$, when Mercury's latitude, by the former, must have been $15'\ 58'', 257$, and by the latter, $15'\ 56'', 752$, the mean of which, $15'\ 57'', 504$, may be called Mercury's true latitude by observation, at the time of the ecliptic conjunction. By M. de la *Lande's* tables it was $15'\ 51'', 524$; so that the error in the tables, by this mean, is — $5'', 98$.

For Mercury's heliocentric latitude, according to the observed geocentric latitude.

Mercury's distance from the sun, 31198 : Mercury's distance from the earth 67681 :: Mercury's geocentric latitude at the ecliptic conjunction, by observation, $15'\ 57'', 504 = 957'', 504$: Mercury's heliocent. lat. by observation, $2077'', 2 = 34'\ 37'', 2$.

For the place of the ascending node by observation.

Let ☊E, in Plate II. Fig. IV. be a portion of the ecliptic; the point ☊ the place of ☿'s ascending node; ☊☿ a portion of ☿'s heliocentric orbit; the point at ☿ his heliocentric place in his orbit, at the time of the ecliptic conjunction, and E his place reduced to the ecliptic; E☿ his heliocentric latitude; the angle E☊☿ the inclination of his orbit, by modern Astronomers generally determined to be $7°\ 0'\ 0''$. In the right-angled spheric triangle E☊☿, right-angled at E, there are given the angle E☊☿, and the perpendicular or side E☿, to find the base or side ☊E.

Radius,			
: Tang. E☿ or ☿'s heliocentric lat.	$34'\ 37'', 2$	8	0030458
:: Tang. Co-inclination ☿'s orbit,	$83°\ 0\ 0$	10	9108562
: Sine base ☊E or ☿'s dist. from asc. node,	$4\ 42\ 16$	8	9139020

As

As Mercury's heliocentric motion was in the order of the ſines, and he had paſſed the node, ſubtract this diſtance from his heliocentric longitude, and the remainder will be the point ☊ of the ecliptic, or place of Mercury's aſcending node.

Mercury's heliocentric longitude,	$1^{s}\cdot20^{\circ}26'\ 36''$
Subtract ☿'s diſtance from ☊,	4 42 16
Place of ☿'s aſcending node by obſervation,	1 15 44 20
Ditto by M. de la *Lande's* tables,	1 15 45 54

VIII. *Obſervations of a Solar Eclipſe, October 27, 1780, made at* St. John's *Iſland, by Meſſ'rs.* CLARKE *and* WRIGHT. *In a Letter from Mr.* JOSEPH PETERS *to* CALEB GANNET, *A. M. Rec. Sec. Amer. Acad.*

Halifax, (Nova-Scotia) 27th *Auguſt* 1781.

SIR,

SOME time in the beginning of this ſummer, Mr. *Winſlow* ſhewed me a paragraph of a letter from you, requeſting him, if he could, to obtain the minutes of ſome obſervations of the eclipſe of the ſun, which happened the 27th of October, 1780. I am ſo unfortunate as not to have any kind of apparatus for obſervations of that ſort; nor is there, that I know of, in this place, any thing of the kind,—theſe things, however uſeful, as well as pleaſing, being very little attended to in this place.

Since the ſaid application from Mr. *Winſlow,* I have received from my friend, Doctor *John Clarke,* who was educated in your College, ſome minutes of an obſervation of the fore-mentioned eclipſe, made by himſelf and a Mr. *Wright,* at *Charlotte-town,* on the iſland of *St. John,* in the gulph of *St. Laurence.* I take the liberty to incloſe you a copy of them.

Dr. *Clarke* ſays, that the obſervation was made with a reflecting teleſcope, two feet long, and compleatly fitted for the purpoſe. A clock was regulated with great accuracy, by means of double altitudes of the ſun, taken on ſeveral days before and on the day of the eclipſe. The obſervers were deficient only in a micrometer to meaſure the quantity. They eſtimated it at 11 digits.

Charlotte-town,

Charlotte-town, by obſervations of Mr. *Wright*, is in latitude 46° 13′ north, and 62° 50′ weſt longitude from *London*.

This obſervation agrees well with the beſt judgment I could frame of this eclipſe, at *Halifax*, by a good watch, regulated by the beſt time pieces here, to as great exactneſs as was in my power; except the quantity, which muſt be ſomething greater here, than at the iſland. I projected this eclipſe to be 11 dig. 30′ here, and by the beſt obſervations I could make, that was very nearly its real quantity.

I am aſſured by Mr. *Pool*, of *Yarmouth-Jebouge-Harbour*, on the weſtern coaſt of this province, that the eclipſe there was total for a momentary ſpace.

This, Sir, is the beſt account I am able to give concerning the phaſes of this eclipſe in theſe parts; which, if it prove uſeful in ſcience, or ſatisfactory to you, I ſhall think myſelf happy in having the opportunity of communicating it.

The town of *Halifax*, from obſervations of Mr. *Deſbarres*, is in 44° 44′ north latitude, and 63° 30′ 30″ weſt longitude from *London*.

I am, Sir, your moſt obedient
And very humble ſervant,
JOSEPH PETERS.

To Mr. *Caleb Gannett*.

The following are the obſervations made by Meſſ'rs. *Clarke* and *Wright*:

	App. Time.
Beginning of the eclipſe,	11h. 41′ 35″ A.M.
☽'s ſouthern limb at letter *a*, Plate II. Fig. V.	11 56 30
Ditto in contact with *b*,	12 59 2

☽'s

	App. time.
☽'s western limb quitted *d*,	1h 28′ 38″ A.M.
Ditto quitted *b*,	1 35 13
End of the eclipse,	2 17 41
Duration,	2 36 6

They missed the contacts with *c* by altering the position of the telescope.

IX. *Obſervations of a Solar Eclipſe, October 27, 1780, made at the Univerſity in* Cambridge. *Communicated by* CALEB GANNETT, *A. M. Rec. Sec. Amer. Acad.*

ON ſeveral days previous to the eclipſe, I carefully took correſponding altitudes of the ſun, with an excellent *Hadley's* quadrant. The agreement between the obſervations was ſuch, that thoſe taken on the two immediately preceding days, expreſs the reſult of the whole. They were as follow:

Oct. 25,	A. M.	P. M.		
	8h 59′ 19″	2h 50′ 1″	Hence, at app. noon the clock was	11h 54′ 40″
	8 56 1	2 53 11	Interval	5 57 40
	8 52 10	2 57 18	½ ditto	2 58 50
			Equation of ½ intervals	+ 16
Sum,	26 47 30	8 40 30		
				11 54 56
Mean,	8 55 50	2 53 30		
			Clock ſlow of ſun,	5 4

Oct. 26,	A. M.	P. M.			
	8 48 1	3 1 18	Hence, at app noon the clock was	11 54 36	
	8 52 11	2 57 1	Interval	5 56 8	36‴
	8 56 47	2 52 23	½ ditto,	2 58 4	18
	9 0 58	2 48 11	Equation of ½ interval	+ 16	
	9 4 42	2 44 29			
				11 54 52	
Sum,	44 42 39	14 23 22			
			Clock ſlow of ſun,	5 8	
Mean,	8 56 31 48‴	2 52 40 24‴			

On the 27th, obſervations were taken in the morning; but the atmoſphere was ſo loaded with vapour, as to prevent the taking of any, with accuracy, in the afternoon.

From the above obſervations it appears, that between the 25th and 26th of October, the clock gained on mean time 2″. Hence, on the 27th, at apparent noon, the clock was ſlow of the ſun 5′ 11″. Two common braſs reflecting teleſcopes were uſed upon the occaſion, each magnifying about 60 times; alſo,

an

an achromatic, made by *Dolland*, it's magnifying power 90. The Reverend Profeſſor *Wiggleſworth* and Mr. *John Mellen*, uſed two of the teleſcopes. Mr. *Mellen* obſerved with the achromatic.

The obſervers were ſo unfortunate as not to perceive the beginning of the eclipſe. They ſuppoſed the ſhadow would have entered the ſun's diſc more weſterly than it did.—They therefore attended to a different part of the ſun's limb. To prevent a ſimilar error in future, it might be well, previouſly, to determine the point at which an eclipſe will commence. This may be done by calculating the angle, which the ecliptic will make with a vertical circle paſſing through the centre of the ſun, at the time the eclipſe begins.

The obſervations were as follow, viz.

Obſervers,	*Wiggleſworth.*	*Gannett.*	*Mellen.*	Mean of obſ.
		Apparent Time.		
	h. ′ ″	h. ′ ″	h. ′ ″	h. ′ ″
Firſt contact of N. W. ſpots, Plate II. Fig. VI.	11 20 57		11 21 3	11 21 0
Total obſcuration of ditto,	11 25 15		11 25 36	11 25 $25\frac{1}{2}$
Firſt cont. of N.E. ſpots, No. 1,	11 31 36	11 31 53	11 31 38	11 31 $42\frac{1}{3}$
2,		11 33 4		11 33 4
3,		11 33 54		11 33 54
Total obſcuration of 4,	11 34 52		11 34 58	11 34 55
Firſt cont. of central ſpot,	11 35 26	11 35 30	11 35 30	11 35 $28\frac{2}{3}$
Total obſcuration of ditto,	11 36 19	11 36 4	11 36 14	11 36 $12\frac{1}{3}$
Firſt cont. of S. E. ſpot,		12 13 47	12 13 47	12 13 47
Total obſcuration of ditto,		12 14 3	12 14 4	12 14 $3\frac{1}{2}$
Total emerſion of N. W. ſpots,	12 29 28			12 29 28
Firſt app. of N. E. ſpots, No. 1,	12 52 56	12 52 33	12 52 31	12 52 $36\frac{2}{3}$
2,		12 53 27		12 53 27
3,		12 54 9		12 54 9
Total emerſion of 4,	12 55 23		12 56 4	12 55 $43\frac{1}{2}$
Firſt app. of central ſpot,		12 56 11		12 56 11
Total emerſion of ditto,	12 56 47	12 56 45		12 56 46
Firſt app. of S. E. ſpot,		1 33 51	1 33 47	1 33 49
Total emerſion of ditto,	1 34 1	1 34 5		1 34 3
End of the eclipſe,	1 39 51	1 39 47	1 39 50	1 39 $49\frac{1}{3}$

Digits eclipſed, about $11\frac{2}{5}$.

The obſervers not being poſſeſſed of a micrometer, Mr. *Wiggleſworth* made uſe of the following expedient to determine

the quantity of the eclipſe.—He deſcribed on paper a number of circles, dividing a common diameter into digits. The paper was placed perpendicular to a teleſcope, through which the ſun's rays were received upon it. Accuracy is not pretended in this method. The quantity noted, is the neareſt that could be eſtimated by it.

Through want of croſs wires in either of the teleſcopes uſed, the preciſe ſituation of the ſpots, on the ſun's diſc, could not be determined. In the figure, their relative ſituation is marked, according to judgment at the time.

X. *An Observation of a Solar Eclipse, October 27, 1780, at* Providence. *By* JOSEPH BROWN, *Esquire.*

MY apparatus for the observation of the solar eclipse was a three-feet reflecting telescope, with spirit levels; a small graduated semi-circle of about $4\frac{1}{2}$ inches radius, and rack motions for taking altitudes; and a glass micrometer, fitted with rack motions, I believe of *Dolland's* construction, having a nonius graduated to $\frac{1}{300}$ part of an inch: A reflecting telescope of near two feet; and a prospect-glass of three feet four inches length, which I mounted on a convenient stand.

On the 20th, I moved my clock into a convenient part of my house; and from that time to the day of the eclipse, I was constantly employed in taking corresponding altitudes of the sun with my telescope, and constructing a meridian-line.

Our observations of the eclipse were as follow:

The beginning was not accurately noted.			
First seen in correct time,	$10^{h.}$	$58'$	$8''$
Just touches a black spot in or near the middle of a macula at the right hand,	11	21	32
Just touches the first of four spots all nearly in a range in a macula at the left hand,	11	30	52
Ditto the spot nearest the centre of the sun's disc,	11	35	20
The end of the eclipse as seen by Mr. *West* in the small telescope,	1	39	1
Ditto by my brother in the spy-glass,	1	39	8
Ditto last seen by myself in the largest reflector,	1	39	16

I

I took the diameter of the ſun while the eclipſe was on, and made it three inches and $\frac{434}{500}$; which, by my table, conſtructed in the year 1769, previous to the tranſit of Venus, makes the ſun's apparent diameter $32' 18''$: And the ſmalleſt I ſaw the bright part of the ſun was $\frac{140}{500}$ of an inch: So ſmall I am certain it was, and it might probably be a very little leſs, tho' I believe this to be pretty exact; and this, I think, makes the ſun to be 11 digits and $\frac{3}{10}$ eclipſed, or very nearly ſo.

XI. *Observations of the Solar Eclipse of the 27th of October, 1780, made at* Newport, Rhode-Island, *by Mons. de* GRANCHAIN. *Translated from the* French, *and communicated by the Reverend President* WILLARD.

	Times per Clock. h.	′	″	True Times. h.	′	″
THE instant when it was perceived that the eclipse had began,*	9	24	32	11	0	12
Preceding limb of the sun at the vertical,	11	21	39	0	57	27
Upper limb of the sun at the horizontal,		21	54		57	42
Upper horn at the horizontal,		22	3		57	51
Limb of the moon at the vertical,		22	45		58	33
Upper horn at the vertical,		23	7		58	55
Lower horn at the vertical, doubtful,		23	35		59	23
Lower horn at the horizontal,		29	31	1	5	20
Lower limb of the sun at the horizontal,		31	2		6	51
Preceding limb of the sun at the vertical,	11	37	12	1	13	1
Upper limb of the sun at the horizontal,		37	59		13	48
Upper horn at the horizontal,		38	32		14	21
Limb of the moon at the vertical,		passed,				
Upper horn at the vertical,		38	57		14	46
Lower horn at the vertical,		39	19		15	8
Lower horn at the horizontal,		43	38		19	28
Lower limb of the sun at the horizontal,		45	27		21	17

N. B. The apparent upper and lower limb of the planet, in the telescope of the quadrant, which inverts objects, is here called the upper and lower limb.

Preceding

* When it was perceived that an impression was made upon the limb of the sun, the eclipse had been begun 1′ 20″; therefore, the true beginning was at 10h 58′ 52″.

Preceding limb of the ſun at the vertical,	11^h 47′ 8″	1^h 22′ 58″
Upper limb of the ſun at the horizontal,	48 17	24 7
Limb of the moon at the vertical,	49 0	24 50
Upper horn at the vertical,	49 5	24 55
Upper horn at the horizontal,	49 7	24 57
Lower horn at the vertical,	49 21	25 11
Lower horn at the horizontal,	52 52	28 42
Lower limb of the ſun at the horizontal,	55 2	30 52
End of the eclipſe,	0 4 50	1 40 41
Latitude of the obſervatory upon *Goat-Iſland*,		41° 30 30

Obſervations of the lunar eclipſe of the 11th of Nov. 1780, made at *Newport*, (*Rhode-Iſland.*) By Monſ. de GRANCHAIN.

	Times per Clock.	True Times.
Beginning of the eclipſe,	7^h 40′ 5″	10^h 24′ 39″
Beginning of the immerſion of *Grimaldus*,	48 50	33 25
End of the immerſion of *Grimaldus*,	51 25	36 10
Beginning of the immerſion of *Tycho*,	8 0 36	10 45 12
The ſhadow of *Galileo*,	3 42	48 18
Beginning of the immerſ. of *Copernicus*,	27 54	11 12 31
End of the immerſion of *Copernicus*,	32 35	17 12
The ſhadow at the middle of *Dionyſius*,	46 55	31 33
The ſhadow at *Promontorium acutum*,	55 42	40 21
Copernicus begins to emerge,	9 17 54	12 2 34
Grimaldus begins to emerge,	22 2	6 42
Copernicus wholly emerges,	23 35	8 15
Grimaldus wholly emerges,	26 45	11 26
Promontorium acutum emer. from the ſhad.	51 12	35 55
Tycho wholly emerges from the ſhadow,	10 10 6	54 51
End of the eclipſe,	32 10	1 16 57

The

The ſame clock and quadrant were made uſe of in this obſervation, which had been uſed for the obſervation of the ſolar eclipſe. The going of the clock was, however, a little different, becauſe it had been altered.

ILLUSTRATIONS OF THE OBSERVATION OF THE SOLAR ECLIPSE.

The clock which was made uſe of to obtain the times, had a compound pendulum-rod, made by Monſ. *Berthoud*, a celebrated clock-maker at *Paris*. It was regulated many days before and after the obſervation, by correſponding altitudes, taken with a quadrant made by *Ramſden*, which was very good and very well divided.

The ſame quadrant was uſed in obſerving the tranſits of the horns, and of the limbs of the ſun and of the moon, acroſs the horizontal and vertical wires of the teleſcope, which was fitted for this purpoſe.

The obſerver, who, in putting on board the aſtronomical inſtruments, had nothing in view but the regulation of marine watches, was not ſo well provided with teleſcopes, as with time-pieces and quadrants. To obſerve the beginning and end of the eclipſe, he was obliged to make uſe of a ſimple achromatic ſea-glaſs, of three and an half feet focus. However, he believes he may anſwer for the end of the eclipſe, within four or five ſeconds nearly. The inſtant of the beginning is much more uncertain. A conſiderable impreſſion was made upon the ſun, before it was perceived. To determine, at leaſt, roughly, the true inſtant of the beginning of the eclipſe, an eſtimation was made, as near as might be, of the diſtance of the horns, at the moment when it was perceived that an impreſſion

was made upon the disc of the sun; and towards the end of the eclipse, it was observed how much time passed from the instant when the distance of the horns was sensibly the same, to the end of the eclipse. It is in this manner that it was determined, that about 1′ 20″ must have intervened, between the true instant of the beginning of the eclipse, and the time when the impression was first observed.

At first it was thought useless to endeavour to observe the quantity of the eclipse with the quadrant, because of the slowness of the motion of the two planets vertically; however, upon reflection, it was thought that the transits of the horns, and of the limbs of the sun and moon across the vertical wire only, would be sufficient to give the differences of the altitudes and azimuths of the centers of the two planets, and, consequently, their differences of latitude and longitude. These were, therefore, observed towards the end of the eclipse, and at the same time, the transits across the horizontal wire were observed, but without hoping that they could be of any great advantage, for calculating the distance of the centers.

In the first observation, the transit of the apparent lower horn across the horizontal wire is a little doubtful: It may therefore be proper to perfer, in the calcule from this observation, the transit of the limb of the moon, and of the apparent upper horn, across the same vertical wire.

In the second observation, the instant of the transit of the limb of the moon across the vertical wire was omitted, through hurry:—To calculate it, therefore, we may make use of the transit of the horn across the same wire.

The last observation, being more complete, we may calculate it by the one or the other method, indifferently; or we

may

may make uſe of the tranſits acroſs the horizontal wire, to deduce the difference of altitude, becauſe the motion of the two planets, vertically, was become leſs ſlow, when this obſervation was made.

If we would, in the firſt obſervation, verify the inſtant of the tranſit of the apparent lower horn acroſs the vertical wire, or know, in the ſecond obſervation, the inſtant of the tranſit of the limb of the moon acroſs the ſame wire, we may eaſily calculate them, with the aſſiſtance of the quantities already known. It will, perhaps, be uſeful to make this calculation, that we may be in a condition of determining the variation, which muſt have taken place, in the poſition of the two planets, obſerved relatively the one to the other, during the ſpace of time which intervened, between their tranſits acroſs the ſame wire.

XII. *An Account of the Observations made in* Providence, *in the State of* Rhode-Island, *of the Eclipse of the Sun, which happened the 23d Day of April,* 1781. *By* BENJAMIN WEST, *Esquire, F. A. A. Communicated by the Reverend President* WILLARD.

I HAVE thought proper to draw up a particular account of this eclipse, as well knowing that proper observations of eclipses make an important article in the theory of astronomy. It was by these kind of observations the lunar theory was bro't to it's present degree of perfection: And every Astronomer knows of what consequence it is to navigation, to have the moon's motion settled to a certain degree of accuracy.

This eclipse was observed in *Providence* by Mr. *Joseph Brown* and myself, at Mr. *Brown's* house. The morning of the 23d of April was cloudy, and I despaired of seeing the sun that day; but a little before twelve o'clock, the clouds seemed to break, and the sun, now and then, made it's appearance, which gave me some hopes of seeing some part of the eclipse: But after twelve o'clock the sun was again obscured by the clouds, and remained so till five or six minutes after the first contact of the sun's and moon's limb, when we had again a slight view of the sun through the clouds, and saw the eclipse was coming on. The air continued unfavourable to our observation till a few minutes before the middle of the eclipse, when the sun again appeared, and gave us a good opportunity of observing the quantity of the eclipse when at the greatest;—for which purpose, Mr. *Brown* applied the micrometer, and found the lucid part of the sun, when in its least state, 1288 microme-

ter

ter measure. This was not done at a single operation, but by a number of trials, till he found the bright part of the sun was in it's least state. After reading off the numbers from the micrometer for the quantity of the eclipse, Mr. *Brown* immediately, at my request, took the length of the chord joining the cusps, which I believe was done with great care, and found it 1380. The micrometer measures for the sun's diameter was 1906. Then 1906 — 1288 = 618, the eclipsed part, and $\frac{618 \times 12}{1906} = 3^\circ\ 53'$ digits for the greatest quantity of the eclipse. From the table which we made for the micrometer in the year 1769, the sun's apparent diameter was 31′ 53″, exactly agreeing with what *Mayer's* tables make it. I found the apparent diameter of the moon by the following method:—Let GFI be the sun, and HEB the moon, and EF the chord joining the sun's cusps. Now, as BG is a straight line, bisecting the straight EF at right-angles, it must therefore pass through the centers both of the sun and moon. (*Euclid* I. III.) The angle ADE is a right-angle, and AE and ED are given quantities. Then $\sqrt{AE^2 - DE^2} = AD$. (Per *Euclid* 47. I.)

AE =	953	
DE =	690	
Sum =	1643	3.2156376
Difference =	263	2.4199557
		2)5.6355933
AD =	657,2	2.8177966
AG =	953	
DG =	1610,2	
GH =	1288	
HD =	322,3	

The

The angle BEH, in a ſemi-circle, is a right-angle, (*Euc.*31. III.) and HD, DE, DB, are three proportionals, (*Euc.*8. VI.) that is to ſay, HD : DE :: ED : DB.

DE =	690	2.8388491
		x 2
		5.6776982
HD	322,3	2 5082603
BD =	1477,2	3 1694379

HB = 1299,5 the micrometer meaſure for the moon's diameter. It is a thing well known to mathematicians, that the ſines of ſmall arcs are nearly equal to the arcs themſelves; hence we have a rule to find the moon's apparent diameter by proportions.

☉'s micrometer meaſure	1906,	Log.	3 2801
It's ∠,	31′ 53″,	LL	7517
☽'s micrometer meaſure	1799,5	6° ar.	6 7449
☽'s apparent diameter,	30′ 6″,	LL	7767
Deduct	— 23	for the moon's elevation.	
☽'s horizontal diam.	29 43,	but one ſecond more than what	

is given from *Mayer's* tables.

Mr. *Brown* and myſelf both noted the ſame ſecond for the laſt contact, which was at $2^h\ 53'\ 36''$ apparent time. There were ſome thin white clouds about the ſun, yet I think the obſervation was pretty good.

XIII. *Account of the Tranſit of Mercury, obſerved at* Cambridge, *November* 12, 1782. *By* JAMES WINTHROP, *Eſquire, F. A. A.*

THE following obſervations were made at the houſe of the Reverend Profeſſor *Williams*. We uſed the ſame clock, but obſerved the tranſit from different parts of the houſe. The clock was regulated by the Profeſſor, who reduced all the obſervations to apparent time. Mine were as follow:

Firſt external contact,	10^h 6′ 31″ A.M.
Firſt internal contact when the thread of light was formed, and Mercury recovered his roundneſs,	10 12 13
Mercury begun to appear oblong before the ſecond internal contact,	11 21 41
Doubtful whether the thread of light was broken,	11 22 44
Second internal contact when the thread of light was compleatly broken,	11 23 5
Second external contact,	11 29 19

The magnifying power of the reflecting teleſcope uſed in theſe obſervations, was 260. The elliptical appearance of the planet was obſerved by Mr. *Williams* as well as myſelf, at both paſſages over the ſun's limb; but I do not recollect to have ſeen it remarked of any former tranſit of this planet. An idea that the ſmallneſs of Mercury's apparent diameter and the rapidity of his motion would not ſuffer it to be of any long continuance, prevented my making more particular remarks at the time of the ingreſs. The certainty of a ſufficient interval between

tween the laſt contacts, enabled me to attend more particularly to this obſervation at the end, than at the beginning of the tranſit. At $11^h 21' 41''$ apparant time, Mercury began to appear diſtorted; and from this time the thread of light grew gradually fainter till $11^h 22' 44''$, when I was doubtful whether it exiſted any longer. I ſet down the ſecond internal contact at $11^h 23' 5''$, when I was firſt certain that the thread of light was broken. From the time that the center of the planet appeared to me to have paſſed the ſun's limb, the appearance of it's following half became very irregular, being diſturbed by a briſk undulatory motion, which continued till the end of the tranſit.

This diſtortion appears to be common to both the inferior planets, when in the ſame ſituation with reſpect to the obſerver. At the tranſit of Venus in 1761, it was obſerved in *India*, *England* and *Sweden*; and at that of 1769, by almoſt all who obſerved the tranſit. They indeed vary in their ideas of its duration; which cannot be wondered at when we conſider the different magnifying power of their inſtruments, and the different ſtrength of their eyes. Particular deſcriptions of the appearance of Venus, in her two tranſits, are publiſhed in Vols. LIX. LX. and LXI. of the Philoſophical Tranſactions, with ſuitable projections; and from the great reſemblance they bear to the appearance of Mercury in his laſt tranſit, the concluſion is natural that they aroſe from the ſame cauſe.

The object is ſo ſmall and remote, that we can hardly expect to determine it's cauſe with abſolute certainty. It will not, however, be deemed amiſs to remark, as a *probable* cauſe only, that the rays proceeding from ſo ſmall an object as that part of the ſun's limb which is neareſt to the planet, during the diſtortion of the latter, are too feeble to make a full impreſſion

preffion on the feat of vifion. Objects feen by reflection, as moft terreftrial bodies are, cannot be feen diftinctly, unlefs they fubtend a certain angle. The fame thing taking place in luminous objects, with a fmaller angle, when the thread of light becomes too fmall to be diftinctly feen, the exterior limb of the planet will appear confufed ; and every degree of confufion, arifing from a partial defect of light, will operate upon the eye like a real diftortion of the object. If this opinion be right, as the diftance of centers is eafily calculated for any given moment, perhaps the limits of vifion, as far as refpects luminous objects, may be afcertained by accurate obfervations of this kind.

Cambridge, 27th December, 1783.

XIV. *Observations of an Eclipse of the Moon, March 29, 1782, and of an Eclipse of the Sun, on the 12th of April following, at* Ipswich, *Lat.* 42° 38′ 30″. *By the Reverend* MANASSEH CUTLER, *F. A. A.*

IN the following observations I made use of a reflecting telescope, made by *Mann*, magnifying 45 times. My clock was carefully regulated by taking corresponding double altitudes of the sun, reflected from a bowl of the oil of tar, with *Hadley's* quadrant.

The night of 29th of March was exceedingly clear, and the atmosphere very free from vapour. At 2h. 15′ 1″ apparent time, I observed a dusky appearance on the part of the moon's limb, which was then just within the lower part of the field of my telescope; and, bringing it instantly into the center of the field of view, found the penumbra considerably advanced, and in about 42″ perceived an impression from the shadow.

Apparent Time.			
At 2h.	15′	1″	discovered the penumbra somewhat advanced.
2	15	42	eclipse began.
2	21	17	in contact with *Gasseudus*.
2	25	37	in contact with *Mare Humorum*.
2	30	31	in contact with *Tycho*.
2	33	30	in contact with *Grimaldus*.
2	34	35	in contact with *Pitatus*.
2	40	11	*Grimaldus* covered.
2	54	55	in contact with *Snellius et Furnerius*.
3	2	1	in contact with *Keplerus*.
3	10	23	*Dionysius* covered.
3	14	2	*Promontorium Acutum Censorinus* covered.

Apparent

Apparent Time.			
At 3^{h}	$24'$	$13''$	*Manilins* covered.
3	26	30	*Plinius* covered.
3	31	9	in contact with *Mare Crisium*.
3	40	20	*Grimaldus* begins to emerge.
3	53	54	emersion of *Manilins* and *Plinius*.
4	45	40	emersion of *Mare Nectaris*.
4	51	25	emersion of *Snellius et Furnerius*.
4	55	20	eclipse ends.
4	57	5	day-light so far advanced that the penumbra could no longer be perceived.

On the 12th of April I was favoured with the company of the Reverend Mr. *Prince*, of *Salem*, and Mr. *Brown Emerson*, of *Reading*, who observed the eclipse with me. Mr. *Prince* made use of a reflecting telescope, the magnifying power not known, but supposed to be about 45. Mr. *Emerson* observed with a reflector, made by *Mann*, magnifying 34 times.

The day was fine, and the sky unusually clear in the morning; but before twelve o'clock the sun was frequently covered with detached flying clouds. Just at the time the eclipse began, however, the sun was free from any cloud and excellently defined. I was so fortunate as to have the point in the sun's limb, where the contact took place, full in the field of view, and noted the second that was called when I first suspected an impression, though I was not certain of the contact for the space of two or three seconds after. Before the eclipse ended, the wind breezed up fresh, and the vapour increased so as to occasion a constant undulation of the sun's limb. We were, therefore, not so certain about the time of the ending, as we were of the beginning of the eclipse.

	Mr. *Prince*.	Mr. *Emerson*.	Myself.	
Beginning,	0h 12′ 52″	0h 12′ 48″	0h 12′ 46″	Apparent time.
End,	2 53 19	2 53 6	2 53 15	
Duration,	2 40 27	2 40 18	2 40 29	

The latitude of my house has been found, by the mean of about twenty double altitudes of the sun, when on the meridian, taken with an *Hadley's* quadrant, to be 42° 38′ 30″.

XV. *On the Extraction of Roots. By* BENJAMIN WEST, *Esquire, F. A. A. In a Letter to Mr.* CALEB GANNETT, *Rec. Sec. F. A. A.*

DEAR SIR,

HAVING a little leisure at this time, I thought it a proper opportunity to fulfil my promise of sending you the substance of what I have done, respecting the Roots. What I chiefly aimed at was, to render the method of extracting the roots of the odd powers easier, and less burthensome to the memory ; and, I think, I have not failed in my attempt. The method, followed by *Ward* and others, is excellent, but is attended with too much difficulty in getting the divisors ; especially for learners, who are not acquainted with the reason of the rules.—That difficulty I have strove to remedy in the following work. In the course of my teaching, since I made this discovery, I have not met with more trouble in teaching the third, fifth and seventh powers, than what is usual in extracting the square root. Methods, similar to these, may be found for extracting the roots of the even powers.

I generally get the three first figures in the root by the first operation, (if there are so many in the root) tho' many times four or five may be got, if the first figure in the root comes very near to the first period of the resolvend.

As it is not necessary to make a long introduction, I shall proceed to show in what manner I investigated the rules. The cube root being the first in order, I shall begin with that ; and in order thereto, let the resolvend be $= a$; the first figure in the root $= r$; and the remaining figures in the root $= e$; and then

then the root will be $r+e$; and, by involution $r^3+3r^2e+3re^2+eee=a$. By dropping e^3, and making the other terms equal to a, we ſhall have $r^3+3re^2+3re=a$; and by ſubtraction $3re^2+3re^2=a-r^3$; and by diviſion $e^2+re=\frac{a-r^3}{3r}$; and by compleating the ſquare, we ſhall have $e^2+re+\frac{r^2}{4}=\frac{a-r^3}{3r}+\frac{r^2}{4}=\frac{4a-r^3}{12r}$; by extracting the ſquare root of both ſides, it will give $e+\frac{r}{2}=\sqrt{\frac{4a-r^3}{12r}}$; whence $e=-\frac{r}{2}+\sqrt{\frac{4a-r^3}{12r}}$; and by the addition of r on each ſide, it will be $r+e=r-\frac{r}{2}+\sqrt{\frac{4a-r^3}{12r}}=\frac{r}{2}+\sqrt{\frac{4a-r^3}{12r}}$. From which comes this rule:

Take the neareſt root to the firſt period of the reſolvend, be it more or leſs than juſt, and ſupply it with as many cyphers as there are remaining periods in the reſolvend, and call it the aſſumed root. Then multiply the given reſolvend by 4; from the product ſubtract the cube of the aſſumed root; divide the remainder by 12 times the aſſumed root, and extract the ſquare root of the quotient. To the ſquare root, thus found, add one half of the aſſumed root, and it will give the cube root corrected; which may be repeated and carried to what exactneſs you may wiſh to have it;—always taking the laſt root for the aſſumed root.

Take an example or two.—Let it be required to extract the cube root from 735051274. Here 9 is the neareſt root 735, and 900 is the aſſumed root, leſs than juſt.

735051274

```
        735051274(900=assumed root.
               ×4
        ----------
   3    2940205096
900= — 729000000

900×12=108|00)22112050|96(204741
        216····
        ---
        512        4  )    204741(452,
        432        4       16      450=the assumed root.
        ---        --      ---
        800        85      447     902=true root, nearly.
        756        5       425
        ---        ---     ----
        445        902     2241
        432                1804
        ---                ----
        130                437
        108
        ---
        22
```

Take a second example. Extract the cube root from 330625.

```
        330625(70=assumed root, more than just.
            ×4
        -------                                   The work repeated,
   3    1322500
 70 = — 343000                                         69,1
                                                       69,1
70×12=84|0)97950|0 (   1166,07 (34,1                   ----
        84···    3     9        35,=½70                691
        ---      3     ---      ------                6219
        139      --    266      69,1 corrected.       4146
        84       64    256                            -------
        ---      4     ----                           4774,81 square.
        555      ---   1007                             69,1
        504      681   681                            -------
        ---            ---                            2864886
        510            326                            429733
        504                                           4774
        ---                                           --------
        600                                           329939,3 cube.
        588
        ---
        12
```

1322500

$69,1^3 = 1322500 - 329939,3$

$69,1 \times 12 = 829,2)992560,7(1197,010009647852$

8292			
16336	3)	1197,010009647852(34,597832	
8292	3	9	$34,55 = \frac{1}{2} 69,1$
80440	64	297	69,147832 root.
74628	4	256	
58127	685	4101	
58044	5	3425	
8300	6909	67600	
8292	9	62181	
80000	69187	541909	
74628	7	484309	
53720	691948	5760064	
49752	8	5535584	
39680	6919563	22448078	
33168	3	20758689	
65120	69195662	168938952	
58044		138391324	
70760		30547628	
66336			
4324			
4146			
178			
165			
13			

Two examples being ſufficient to illuſtrate the rule, I ſhall proceed to the ſurſolid, or fifth power. The inveſtigation is as follows:

Let $a =$ the reſolvend; $r =$ the firſt figure in the root, and $e =$ the remaining figures. Then $r + e =$ true root, and $r^5 + 5r^4e + 10r^3e^2 + 10r^2e^3 + 5re^4 + e^5 = a$; and by dropping all the terms that contain a higher power of e than e^2, and by

by making the remainder equal to a, there will be $r^5 + 5r^4e + 10r^3e^2 = a$, and then $5r^4e + 10r^3e^2 = a - r^5$; and by division $e^2 + \frac{1}{2}re = \frac{a-r^5}{10r^3}$; and by compleating the ſquare we ſhall have $e^2 + \frac{1}{2}re + \frac{r^2}{16} = \frac{a-r^5}{10r^3} + \frac{r^2}{16} = \frac{16a-6r^5}{160r^3} = \frac{8a-3r^5}{80r^3}$*; and by extracting the ſquare root, $e + \frac{r}{4} = \sqrt{\frac{8a-3r^5}{80r^3}}$; and by ſubtraction $e = -\frac{r}{4} + \sqrt{\frac{8a-3r^5}{80r^3}}$; and by adding r on both ſides; $r + e = r - \frac{r}{4} + \sqrt{\frac{8a-3r^5}{80r^3}} = \frac{3}{4}r + \sqrt{\frac{8a-3r^5}{80r^3}}$. Whence this rule:

Take the neareſt root to the firſt period of the reſolvend, more or leſs than juſt, and annex as many cyphers, as there are remaining periods in the reſolvend, and call it the aſſumed root. Multiply the reſolvend by 8, and from the product take 3 times the fifth power of the aſſumed root; divide the remainder by 80 times the third power of the aſſumed root, and extract the ſquare root of the quotient; to which add three fourths of the aſſumed root, and it will give the furſolid root corrected:—It may be repeated, and carried to what exactneſs you would have it; ſtill taking the laſt root from the aſſumed root.

Let us take an example from *Ward*: Extract the ſurſolid root from 12309502009375. Here the neareſt ſurſolid root to 1230 is 4, and the aſſumed root 400, leſs than juſt.

* The co-efficients are divided by their greateſt common meaſure. *Euc.*b. 7. p. 3.

```
                      12309502009375 (400=assumed root.
                                  x8
                  ———————————————
        5             98476016075000
   400x3=— 30720000000000
   3              ———————————————
400x80=512.0000000)6775601|6075000 (   13233 ( 115
                   512····                 1        300
                   ———            1       —        ———
                   1655           1       32       415 = root.
                   1536           —       21
                   ————          21      ———
                    1196          1      1133
                    1024          ———    1125
                    ————         225     ———
                    1720                   8
                    1536
                    ————
                     1841
                     1536
                     ————
                      305
```

One caſe being ſufficient to exemplify the rule, I ſhall not trouble you with a ſecond. The next is the ſecond ſurſolid, or ſeventh power: And let the ſame letters ſtand for the ſame things, as in the preceding powers; and then we ſhall have $r^7 + 7r^6e + 21r^5e^2 + 35r^4e^3 + 35r^3e^4 + 21r^2e^5 + 7re^6 + e^7 = a$; and by neglecting all the terms that contain a greater power of e than e^2, and making the remainder equal to a, there will ariſe $r^7 + 7r^6e + 21r^5e^2 = a$; and $7r^6e + 21r^5e^2 = a - r^7$; and by diviſion $e^2 + \frac{1}{3}re = \frac{a-r^7}{21r^5}$; and by compleating the ſquare, $e^2 + \frac{1}{3}re + \frac{r^2}{36} = \frac{a-r^7}{21r^5} + \frac{r^2}{36} = \frac{12a-5r^7}{252r^5}$:* By extracting the ſquare root of both ſides of the equation, there will ariſe $e + \frac{1}{6}r = \sqrt{\frac{12a-5r^7}{252r^5}}$; and $e = -\frac{1}{6}r + \sqrt{\frac{12a-5r^7}{252r^5}}$. And furthermore, if r be added to both ſides of the equation, there will be had, $r + e = r - \frac{1}{6}r + \sqrt{\frac{12a-5r^7}{252r^5}} = \frac{5}{6}r + \sqrt{\frac{12a-5r^7}{252r^5}}$. Whence this rule:

Take

* See note, p. 166.

Take the neareſt ſecond ſurſolid root to the firſt period of the reſolvend, and place as many cyphers at it's right hand as there are remaining periods in the reſolvend, and call it the aſſumed root. Multiply the reſolvend by 12, and take 5 times the ſeventh power of the aſſumed root from the product, and divide the remainder by 252 times the fifth power of the aſſumed root; extract the ſquare root of the quotient, and add the root to $\frac{5}{6}$ of the aſſumed root, and it will give the ſecond ſurſolid root corrected; which may be repeated and carried to the deſired accuracy,—remembering to take, in each operation, the laſt root for the aſſumed root. We will take *Ward's* example, viz. Extract the ſecond ſurſolid root from $38\dot{2}9865539\dot{5}5078\dot{1}25$ Here the neareſt root to 3829, is 3, and 300 is the aſſumed root, leſs than juſt.

$$3829865539550781\dot{2}5\,(300$$
$$\times 12$$
$$45958386474609375 00$$
$$300^7 \times 5 = -\,1035000000000000000$$
$$300^5 \times 252 = 61236)0000000000)35023386474609375 00(57\dot{1}\dot{9}$$
$$306180\cdots$$
$$440538$$
$$428652$$
$$118866$$
$$61236$$
$$576304$$
$$541124$$
$$35180$$

$$7\ )\ 57\dot{1}\dot{9}\ (\ 75$$
$$7 \qquad 49 \qquad 250 = \tfrac{5}{6} \text{ of the aſſumed root.}$$
$$145 \qquad 819 \qquad 325 = \text{root, agreeable to } \textit{Ward}.$$
$$725$$
$$94$$

SCHOLIUM.

It may be observed, that in the foregoing examples, I have carried the work out at large: This I did in order to avoid any seeming embarrassments. Whatever contractions are made use of by *Ward*, or others, may be adopted, with equal propriety, in these methods; and I have not met with an instance, in which these rules do not approach the root with equal celerity, as those of the forementioned author.

I am, &c.

BENJAMIN WEST.

To Mr. *Caleb Gannett*.

XVI. *A new and concise Method of computing Interest at Six per Cent. per Annum.* By PHILOMATH.

LET the interest of £.745 be required for 16 months at 6 per cent. per annum.

Operation at large.—According to the double Rule of Three, or (as it is sometimes called) the Rule of Five, the question will be stated thus:

If £.100 in 12 months gain £.6, what will £.745 gain in 16 months?

For solution.—Of these five terms so ranged,

$$\overset{£.}{100} : \overset{m.}{12} : \overset{£.}{6} : \overset{£.}{745} : \overset{m.}{16},$$

the three last are to be multiplied together, for a dividend; and the two first for a division: And the quotient will be the answer to the question. Thus,

```
                        745
                         16
                      -----
                       4470
   100                 745
    12                -----
  -----                11920
   200                     6
   100                -----
  -----                71520 ( £.59
  1200 )               6000
                      -----
                       11520
                       10800
                      -----
              Remain.    720
                          20
                      -----
                     )14400 ( 12s.
                       1200
                      -----
                        2400
                        2400
                      -----
            Answer, £.59 12 0
```

If

If the dividend and divisor, in the foregoing operation, be lessened in the same proportion, or, like parts, be taken instead of their wholes, as, if one sixth part of the former dividend be divided by one sixth part of the former divisor, the quotient and answer will be the same as before. But the product of the two last terms in the stating (omitting the multiplication by the third term 6) is equal to one sixth of said dividend :— Therefore, if the product of said two last terms be divided by 200, equal to one sixth of the former divisor, the quotient and answer will be as before. Thus,

```
             745
              16
            ----
            4470
             745
            ----
    200 )  11920 ( £.59
            1000
            ----
            1920
            1800
            ----
Remain.      120
              20
            ----
            2400 ( 12s.
             200
            ----
             400
             400
```

If instead of the dividend 11920, in the last operation, being divided by 200, it be divided by one of the two numbers, *e. g.* 10 and 20, the rectangle whereof is equal to 200, the divisor there, and the quotient thence arising be divided by the other of said two numbers, the last quotient and answer will be the same as before. Thus,

```
10)11920 ( 1192
   10...
   ---
   19
   10        20)1192(£.59
   ---          100
    92          ---
    90          192
    ---         180
    20          ---
    20          12s.
```

Note here.—The first quotient is ſhillings, it taking 20 of them in the ſecond diviſion to make a pound; and the remainder, after the firſt diviſion, (if any) expreſſes tenths of a ſhillings.

Again.—Inſtead of the former dividend, 11920, being divided by 200, if one half ſaid dividend, or, half the product of the two laſt terms of the ſtate of the queſtion, (which is equal to the product of either of the ſaid two laſt terms multiplied into half the other) be divided by half the ſaid diviſor 200, = 100, there will be the ſame quotient and anſwer as before. Thus,

```
        200     11920
        ---     -----
        100 )   5960(£.59
                500
                ---
                960
                900
                ---
Remain.          60
                 20
                ---
               1200 ( 12s.
               100
               ---
               200
               200
```

From the premiſes reſult the following rules for computing intereſt at 6 per cent. per annum, in a *new conciſe method*, made uſe

uſe of by many gentlemen, but which is not commonly known.

1. If any ſum of money be multiplied by the number of months and parts of a month it is at intereſt, at the rate of 6 per cent. per annum, and the right-hand figure of the pounds in the product be ſeparated by a comma from the others, (if any be) thoſe other figures will be the ſhillings which the intereſt doth come to for the time given, and the right-hand figure, ſeparated as aforeſaid, will be the decimal, that is, the tenth part of a ſhilling.

Example. What is the intereſt of £.745, for 16 months, at 6 per cent. per annum?

Operation.

	£.745
	16
	4470
	745
20s.	119, 2, 0
Anſ.	59, 12, 0

2. If any ſum of money be multiplied by one half of the time in months and parts of a month it is at intereſt, at 6 per cent. per annum, and the two right-hand figures of the pounds in the product be ſeparated with a comma from the others, (if there be any) thoſe other figures, if any there be, will be the pounds that the intereſt doth come to for the time given; and the right-hand figure, ſo ſeparated, will be the decimal parts of a pound.

Example. What is the intereſt of £.745, for 16 months, at 6 per cent. per annum?

Operation.

Operation.

$$\begin{array}{r} £.745 \\ 8 \\ \hline 59,60 \\ 20 \\ \hline 12,00 \\ \hline \end{array}$$

Anſ. £.59 12

If under either of theſe rules, in the product, there be no figures in the place of pounds, ſupply them by one or two cyphers. If under the ſecond rule, there be but one figure in the place of pounds, ſupply by prefixing one or two cyphers.*

The multiplication of pounds, ſhillings, pence, &c. by months and ſuch number of days as are not an exact half, third part, &c. of a month, may indeed ſometimes prove burthenſome to the mind.

But by the help of the two ſubſequent tables of decimals, one of the parts of a pound, and the other of the parts of a month, the intereſt of any ſum of money, conſiſting of divers denominations of pounds, ſhillings, pence, and even farthings, for any given number of months and days, may, upon the principles on which the ſecond rule aforegoing is founded, by an eaſy proceſs and with ſufficient accuracy, be computed.

* In both theſe rules, the ſum at intereſt is ſuppoſed to be given in pounds, &c. But if the ſum at intereſt be given in dollars, the intereſt thereon may be computed by the ſecond rule; only obſerving, that the figures in the product, (of the ſum by half the time) on the left hand of the comma, will be dollars, and thoſe on the right hand will be the decimal parts of a dollar.

A Table of Decimal Parts of a Pound, or twenty Shillings.

s.	d.	q.		s.	d.		s.	d.		s.	d.		l.	s.	d.	
0	0	1	0010	3	11	1959	8	0	4000	12	1	6042	0	16	2	8084
	0	2	0021	4	0	2000	8	1	4042	12	2	6084		16	3	8125
	0	3	0031	4	1	2042	8	2	4084	12	3	6125		16	4	8167
	1	0	0042	4	2	2084	8	3	4125	12	4	6167		16	5	8209
	2	0	0084	4	3	2125	8	4	4167	12	5	6209		16	6	8250
	3	0	0125	4	4	2167	8	5	4209	12	6	6250		16	7	8292
	4	0	0167	4	5	2209	8	6	4250	12	7	6292		16	8	8334
	5	0	0209	4	6	2250	8	7	4292	12	8	6334		16	9	8375
	6	0	0250	4	7	2292	8	8	4334	12	9	6375		16	10	8417
	7	0	0292	4	8	2334	8	9	4375	12	10	6417		16	11	8459
	8	0	0334	4	9	2375	8	10	4417	12	11	6459		17	0	8500
	9	0	0375	4	10	2417	8	11	4459	13	0	6500		17	1	8542
	10	0	0417	4	11	2459	9	0	4500	13	1	6542		17	2	8584
	11	0	0459	5	0	2500	9	1	4542	13	2	6584		17	3	8625
1	0	0	0500	5	1	2542	9	2	4584	13	3	6625		17	4	8667
1	1	0	0542	5	2	2584	9	3	4625	13	4	6667		17	5	8709
1	2	0	0584	5	3	2625	9	4	4667	13	5	6709		17	6	8750
1	3	0	0625	5	4	2667	9	5	4709	13	6	6750		17	7	8792
1	4	0	0667	5	5	2709	9	6	4750	13	7	6792		17	8	8834
1	5	0	0709	5	6	2750	9	7	4792	13	8	6834		17	9	8875
1	6	0	0750	5	7	2792	9	8	4834	13	9	6875		17	10	8917
1	7	0	0792	5	8	2834	9	9	4875	13	10	6917		17	11	8959
1	8	0	0834	5	9	2875	9	10	4917	13	11	6959		18	0	9000
1	9	0	0875	5	10	2917	9	11	4959	14	0	7000		18	1	9042
1	10	0	0917	5	11	2959	10	0	5000	14	1	7042		18	2	9084
1	11	0	0959	6	0	3000	10	1	5042	14	2	7084		18	3	9125
2	0	0	1000	6	1	3042	10	2	5084	14	3	7125		18	4	9167
2	1	0	1042	6	2	3084	10	3	5125	14	4	7167		18	5	9209
2	2	0	1084	6	3	3125	10	4	5167	14	5	7209		18	6	9250
2	3	0	1125	6	4	3167	10	5	5209	14	6	7250		18	7	9292
2	4	0	1167	6	5	3209	10	6	5250	14	7	7292		18	8	9334
2	5	0	1209	6	6	3250	10	7	5292	14	8	7334		18	9	9375
2	6	0	1250	6	7	3292	10	8	5334	14	9	7375		18	10	9417
2	7	0	1292	6	8	3334	10	9	5375	14	10	7417		18	11	9449
2	8	0	1334	6	9	3375	10	10	5417	14	11	7459		19	0	9500
2	9	0	1375	6	10	3417	10	11	5459	15	0	7500		19	1	9542
2	10	0	1417	6	11	3459	11	0	5500	15	1	7542		19	2	9584
2	11	0	1459	7	0	3500	11	1	5542	15	2	7584		19	3	9625
3	0	0	1500	7	1	3542	11	2	5584	15	3	7625		19	4	9667
3	1	0	1542	7	2	3584	11	3	5625	15	4	7667		19	5	9709
3	2	0	1584	7	3	3625	11	4	5667	15	5	7709		19	6	9750
3	3	0	1625	7	4	3667	11	5	5709	15	6	7750		19	7	9792
3	4	0	1667	7	5	3709	11	6	5750	15	7	7792		19	8	9834
3	5	0	1709	7	6	3750	11	7	5792	15	8	7834		19	9	9875
3	6	0	1750	7	7	3792	11	8	5834	15	9	7875		19	10	9917
3	7	0	1792	7	8	3834	11	9	5875	15	10	7917		19	11	9959
3	8	0	1834	7	9	3875	11	10	5917	15	11	7959	1	0	0	10000
3	9	0	1875	7	10	3917	11	11	5959	16	0	8000				
3	10	0	1917	7	11	3959	12	0	6000	16	1	8042				

A

A Table of Decimal Parts of a Month.

Days.		D.		D.		D.		M.D.	
1	0333	7	2333	13	4333	19	6333	25	8333
2	0667	8	2667	14	4667	20	6667	26	8667
3	1000	9	3000	15	5000	21	7000	27	9000
4	1333	10	3333	16	5333	22	7333	28	9333
5	1667	11	3667	17	5667	23	7667	29	9667
6	2000	12	4000	18	6000	24	8000	1 0	1,0000

When intereſt at the rate of 6 per cent. per annum, is to be computed on any given ſum of money and for any given time, and the money or time, or both, be of divers denominations, ſet down the money at intereſt in pounds and decimal parts of a pound, and the time in months and decimal parts of a month, (the decimals being taken from the tables reſpectively) and multiply the whole of one of them by half of the other, and count off two more of the right-hand figures of the product than there are places of decimals in the multiplicand and multiplier together, and there place a comma, to ſeparate them from the other figures of the product, if any be; but if there be not ſo many figures in the product, ſupply them by prefixing cyphers; and then the figures (if there be any) on the left hand of the comma, will be the pounds that the intereſt comes to for the given time; and the figures on the right hand of the comma will be decimal parts of a pound,—three or four of which, next the comma, may be ſufficient in common caſes to retain, and the reſt may be expunged.

Example. Let the intereſt of £.745 15s. 6d. for 1 year 7 months and 11 days, at 6 per cent. per annum, be computed.

Money.	M. Time.
£.745, 775	2)19, 3667
9, 6833	9, 6833
2237325	
2237325	
5966200	
4474650	
6711975	
72,2156	
20	
4,3120	
12	
3,6440	
4	
2,5760	
Anſ. £.72. 4s. 3d. 2q.	

This method is adapted to reckoning intereſt at the rate of 6 per cent.—But from the intereſt at 6 per cent. the intereſt at any other given rate may be obtained, as follows:

One *ſixth* part of the intereſt at 6 per cent. is the intereſt at 1 per cent.—One *third* is the intereſt at 2 per cent.—One *half* is the intereſt at 3 per cent. If from the intereſt at 6 per cent. there be ſubtracted one *third* of it, the remainder will be the intereſt at 4 per cent.—If one *ſixth* be ſubtracted, the remainder will be the intereſt at 5 per cent.

Again.—If to the intereſt at 6 per cent. there be added one *ſixth* part thereof, the ſum will be the intereſt at 7 per cent.—If there be added one *third*, the ſum will be the intereſt at 8 per cent.—If there be added *half*, the ſum will be the intereſt at 9 per cent.—If two *thirds*, the ſum will be the intereſt at 10 per cent.—If one *half* and one *third*, the ſum will be the intereſt at 11 per cent.—The double of the intereſt at 6 per cent.

cent. is the interest at 12 per cent.—If to that double there be added one sixth of the interest at 6 per cent. the sum will be the interest at 13 per cent. &c.

And this division, addition or subtraction may be made immediately after the first operation of multiplying the money at interest by half the time, or *è contra*, and before the separating the figures into pounds and decimals.

Example. Let there be computed the interest of £.480, for 7 months and 15 days, at 5 per cent. per annum.

```
                 M.
£.480,         7, 50
  3,75        ------
------         3, 75
  2400
 3360
1440
------
180000 at 6 per cent.
 30000 1/6 deduct.
------
15,0000 at 5 per cent.
       Ans. £.15.
```

Example. Let the interest of £.345 15s. for 9 months and 6 days, be computed, at the rate of 7 per cent. per annum.

```
£.345,75     9,20
    4, 60   -----
---------    4,60 half the time.
 2074500
1383000
---------
15904500 at 6 per cent.
 2650750 1/6 add.
---------
18,565250 at 7 per cent.
       20
---------
11,305000
       12
---------
 3,660000
        4
---------
 2,640000
      Ans. £.18 11s. 3d. 2q.
```

Let

Let it be obſerved here,—in this proceſs as well as others, where there are decimals of a pound to be valued, there is no need of the ſeveral multiplications by 20, 12 and 4 for that purpoſe: But the preceding table of decimal parts of a pound being calculated to four places, if we repair to that with ſo many of the decimals (next the comma) to be valued, we ſhall there find their value, by inſpection.

May 15, 1781.

XVII. *Several Ways of determining what Sum is to be insured on an Adventure, that the whole Interest may be covered.* *By* MERCATOR.

1. THE first and most common way is, to cast the premium of insurance at the stipulated rate, on the adventure,—on that premium,—on the premium of the first premium, and so on until the premium be so small as not to be worth noticing; then to collect the adventure and these several premiums (first and secondary) into one sum, which will be the sum to be insured.

Example. Adventure, £.315;—rate of insurance, 30 per cent.

£.315
30
94,50
20
10,00

First premium.
£.94. 10. 0
10
945. 0. 0
3
28,35. 0. 0
20
7,00

Second premium.
£.28. 7. 0
10
283. 10. 0
3
8,50. 10. 0
20
10,10
12
1,20
4
,80

Third premium.
£.8. 10. 1 ¼
3
25. 10. 3. 3
10
2,55. 3. 1. 2
20
11,03
12
,37
4
1,50

Fourth

Fourth premium.

£.2. 11. 0. 2
10
25. 10. 5. 0
3
,76. 11. 3. 0
20
15,31
12
3,75
4
3,00

Fifth premium.

£.0. 15. 3. 3
10
7. 13. 1. 2
3
,22. 19. 4. 2
20
4,59
12
7,12
4
,50

Sixth premium.

£.0. 4. 7. 1
3
0. 13. 9. 3
10
,06. 18. 1. 2
20
1,38
12
4,57
4
2,30

Seventh premium.

£.0. 1. 4. 2
30
,1. 3. 0
10
1. 10
,02. 1. 3. 0
20
,041
12
4,95

Eighth premium.

£.0. 0. 5. 0
30
0. 12. 6. 0
12
1,50
4
2,00

Ninth premium.

£.0. 0. 1. 2
30
1. 3. 0
2. 6.
3. 9. 0
12
,45
4
1,80

Tenth premium.

2 farthings.

Collection.

Adventure,	£.315.	0.	0.	0
1ft. premium,	94.	10.	0.	0
2d.	28.	7.	0.	0
3d.	8.	10.	1.	1
4th.	2.	11.	0.	2
5th.		15.	3.	3
6th.		4.	7.	1
7th.		1.	4.	2
8th.		0.	5.	0
9th.		0.	1.	2
10th.			0.	2
	450.	0.	0.	1

And

And observe :—The greater the rate of insurance, the more operations are requisite ; because the less of the adventure will be covered by the insurance of each preceding premium.

2. Another way.—Cast the premium of insurance on the adventure, (as before) which, subtract from the adventure ;—then, by the Rule of Three, it will be—as that remainder : the adventure :: the adventure : the sum to be insured.

Example. Adventure, £.315.—Rate of insurance, 30 per cent.

£.315	£.315. 0. 0	As £.220. 10s. : £.315 ::	£.315 :
30	94. 10. 0	20	20
94,50	Remain. 220. 10. 0	4410	6300
20			315
10,00			31500
			6300
			18900
		4410)	1984500(450
			17640
			22050
			22050
			000000

The last operation here is best done, in many cases, by decimal arithmetick : Thus,

As 220,5 : 315 :: 315
315
99225

220,5) 99225,0 (450
8820
11025
11025
000000

3. Another and very expeditious way is as follows:

Multiply the adventure by 100; and divide the product by 100 less the rate of insurance, (or, the difference between 100 and the rate of insurance) and the quotient will shew the sum to be insured.

Example. Adventure, £.315. Rate of insurance 30 per cent.

```
 100    315
  30    100
 ---   -----
  70 ) 31500 ( 450
       280..
       -----
       0350
        350
       ----
       0000
```

PART II.

PHYSICAL PAPERS.

1780-1785

I. *Observations upon an Hypothesis for solving the Phenomena of Light: with incidental Observations, tending to shew the Heterogeneousness of Light, and of the electric Fluid, by their Intermixture, or Union, with each other.*

By JAMES BOWDOIN, *Esquire,*
President of the American *Academy of Arts and Sciences.*

IN reviewing some letters I had written to a philosophical friend, Dr. *Franklin*, there occurred on the subject of one of them some observations, which appeared to me new. They are principally contained in the two last of three memoirs, which I shall lay before the Academy: to whose judgment it will be submitted, whether they have any thing beside their novelty to recommend them.

As they were occasioned by considering Dr. *Franklin's* queries concerning light, the strictures on those queries, as being introductory to the observations, will make a part of these memoirs.

The first memoir will accordingly contain a few strictures, or cursory remarks, on his hypothesis for solving the phenomena of light: with incidental observations concerning the hetorogeneousness of light, and the electric fluid.

It is offered in full confidence, that our celebrated countryman, whose happy genius has contributed so largely to the advancement of philosophic knowledge, will be pleased with any attempt for that purpose, whether successful or not, even though it should be upon principles, that may not perfectly harmonize with some of his own.

The Doctor, dissatisfied with the received doctrine concerning light, offers several objections to it in the form of queries; and in the same form proposes an hypothesis of his own: both of which will be considered.

With respect to the hypothesis, it is asked— * "May not all the phenomena of light be more conveniently solved, by supposing universal space filled with a subtle elastic fluid, which, when at rest, is not visible, but whose vibrations affect that fine sense in the eye, as those of air do the grosser organs of the ear? We do not, in the case of sound, imagine that any sonorous particles are thrown off from a bell, for instance, and fly in straight lines to the ear: why must we believe that luminous particles leave the sun, and proceed to the eye? Some diamonds, if rubbed, shine in the dark, without losing any part of their matter. I can make an electrical spark as big as the flame of a candle, much brighter, and therefore visible further; yet this is without fuel: and I am persuaded no part of the electric fluid flies off in such case to distant places, but all goes directly, and is to be found in the place to which I destine it.—May not different degrees of the vibration of the abovementioned universal medium, occasion the appearances of different colours? I think the electric fluid is always the same; yet

* See Letters and Papers on Philosophical Subjects. p. 265. edit. 1769.

yet I find that weaker and ſtronger ſparks differ in apparent colour : Some white, blue, purple, red ;—the ſtrongeſt, white ; weak ones, red."

Several objections here preſent themſelves. Some of them ariſing from the hypotheſis itſelf ; and others from the compariſon of light with ſound.

In reſpect of the former, if univerſal ſpace be filled with a ſubtle elaſtic fluid, (ſo as to exclude any vacuum) that fluid muſt always be at reſt, and therefore by the hypotheſis always inviſible ; and conſequently there would always be univerſal darkneſs. Or if any part of the fluid could be put in motion, the whole of it muſt be in motion : for not one particle of it could move, without moving, in the direction of its motion, the adjoining one, and this the next ; and ſo on, *ad infinitum*. In this caſe, the leaſt motion, wherever it might commence, muſt produce univerſal motion ; and conſequently, univerſal light : between which, and univerſal darkneſs, there could be no medium.

But if the meaning of the expreſſion be, what it was probably intended to be, that univerſal ſpace, inſtead of being filled, doth greatly abound, with an elaſtic fluid, then would not every thing, which diſturbed that fluid, cauſe a luminous appearance ? Would not the inhabitants of the ſea and air, in all their motions, beſpangle both ; and thereby exhibit the various colours according to the different degrees of vibration, which thoſe motions might occaſion in the elaſtic fluid ?—As to ourſelves, would not a radiance attend us wherever we went ? What occaſion ſhould we have of candle-light, when a quick vibration of the hand, or of machines made for that purpoſe, would diſpel the night ? Or rather, might we not ſuppoſe there

there would be no night at all? for the action of the ſun (if the ſun ſhould be neceſſary) would be communicated to us, notwithſtanding the interpoſition of the earth. And would not the effect of that action, even at noon when moſt direct, be only to enlighten us, unattended with heat, ſo eſſentially neceſſary to enliven and invigorate the animal and vegetable world?—Would not the elaſtic fluid, inſtead of exhibiting a round luminous body, which we call the ſun, be itſelf a continued univerſal blaze of light? And would not this, in the preſent conſtitution of things, obſtruct viſion, and totally alter the ſcience of optics?

The objections, implied in the foregoing queries, ſeem deducible from the hypotheſis. There are ſeveral, which appear to ariſe from the compariſon of light with ſound.

1° As ſound (or a vibrating, or undulating, motion in the air, which I conſider here as ſynonimous) is propagated from the ſonorous body in all directions; and ſurrounds, and is propagated beyond or behind any obſtacle in its way: ſo light, if it was a vibration, or undulation, of the elaſtic fluid, would ſurround, and be propagated behind an obſtacle, like ſound: but this does not agree with the fact.—2° As ſound, or the vibrating motion in the air, originating in a houſe or any other incloſure, would, from a hole in one of the ſides of it, be propagated externally, in circles, of which the hole would be the centre: ſo light, if it was a vibration, or occaſioned by a vibration, of the elaſtic fluid, after paſſing through a hole, would be propagated in circles, of which the hole would be the centre. But this does not correſpond to the fact: for light, in paſſing through any uniform medium, always paſſes in right lines.

Beſide

Beside these, an objection similar to one of those, which have been advanced against the common hypothesis, and which may be seen in the proper place, may be alledged against this: for the constant vibration, with which the elastic fluid must be agitated, would communicate to small bodies, and even to large ones suspended in that fluid, a constant tremulous vibratory motion. In such a case it would be difficult to examine the texture and visible qualities of those small bodies, as one necessary mean of examination, a great deal of light, would encrease the vibration; and thereby render the examination not only difficult but impracticable. It is apprehended, however, that no such motion, or embarrassment, in the making of such examinations, has ever been observed.

What is mentioned about the electrical spark, that it is bright, and visible at a distance, and this without fuel; and that no part of the electrical fluid flies off, in such case, to distant places, but all goes directly, and is to be found in the place, to which it is destined, appears to favour the hypothesis; as the implied inference seems to be, that the visibility of the electric spark arises from the vibration it produces in the universal elastic fluid. But if the foregoing queries furnish sufficient reason for doubting the existence of such a fluid, or for doubting such an effect from it, supposing its existence, will they not furnish equal reason for doubting the hypothesis?

The visibility of the electric spark may be accounted for, upon the principles of the received doctrine concerning light, without supposing any diminution of the pure electric fluid in the spark: no part of which, it is said, flies off in the case mentioned.

It ſeems not improbable, that the electric fluid is heterogeneous as well as light.

The heterogeneouſneſs of light is inferred from its colours, which are ſaid to vary proportionably, as the ſize of the particles doth vary: the variation becoming conſpicuous by a priſm, and by other means, which claſs the particles according to their reſpective magnitudes, or degrees of refrangibility, and reflexibility.

Beſide this, another reaſon may be ſuggeſted, from which the heterogeneouſneſs of light may be deduced: namely, becauſe it exhibits effects ſimilar to ſome of thoſe of electricity. For example, a globe or pane of glaſs warmed in the ſun or before a fire, will ſucceſſively attract and repel ſmall cork balls, down, and ſuch like bodies inſulated, and properly circumſtanced; and will ſhew other ſigns of electricity communicated to the glaſs by the ſun or fire.

So, in regard to electricity, its heterogeneouſneſs may be collected from its producing effects reſembling ſome of thoſe of light or fire; which are here conſidered as equivalent terms.

Electricity and fire differ in many reſpects, and in ſome they agree; as hath been ſhewn in Dr. *Franklin's* letters on electricity. So far as they agree in their effects, their nature may be preſumed to be alike: Or rather, from that agreement and ſimilitude of effects, I think it may be inferred, that they are mixt with, and generally do accompany each other; and that each produces its own effect at the time of their joint operation. The effects of electricity, ſimilar to thoſe of fire, being produced by the fire mixt with it; and the effects of fire, reſembling thoſe of electricity, being produced by the electricity mixt with that: the compound taking its name from the predominant principle.

Thus,

Thus, fire inflames bodies, and throws its particles or light at a diſtance. Hence, the exploſion of gun-powder, and the luminous appearance, occaſioned by the electric ſpark : the fire mixt with it producing thoſe effects.

Thus alſo, electricity attracts and repels certain ſmall bodies alternately, under given circumſtances. Hence, the alternate attraction and repulſion of glaſs, and ſome other things, heated by fire : the electricity mixt with the communicated fire producing thoſe effects.

In this way I would infer the heterogeneouſneſs of light and electricity, and their mixture with each other ; and in this way account for the ſimilitude and difference of their effects ; and for the luminous appearance or viſibility of the electric ſpark in particular, without diminiſhing the pure electric fluid contained in it : all of which, in the caſe referred to, is ſaid to go directly, and is to be found in the place, to which it was deſtined.

On the ſame principles the ſhining of diamonds in the dark when rubbed, and thereby electrified, may be accounted for, without ſuppoſing they looſe any part of their matter.

In regard to the different colours of the electric ſpark, which are more or leſs ſtrong according to the ſtrength of the ſpark, they correſpond to the different colours of light or fire, which are more or leſs vivid according to the denſity or intenſeneſs of that element. This ſameneſs of effect ſhews a ſameneſs of cauſe, or that the light or fire mixt with the electric ſpark produces thoſe colours : whoſe ſtrength or vividneſs being according to the bigneſs of the ſpark, or to its quantity of electric fluid, makes it probable, that in proportion to the quantity, there is more or leſs light or fire contained in that fluid.

Theſe different appearances ſeem to be a further inſtance or proof of the heterogeneouſneſs of the electric fluid; and, taken in connection with other appearances above-mentioned, ſhew the intermixture, and the conſequent heterogeneouſneſs, of the two elements.

The next thing to be conſidered is, the objections to the received doctrine concerning light.—But this will be the ſubject of another memoir.

II. *Observations on Light, and the Waste of Matter in the Sun and fixt Stars, occasioned by the constant Efflux of Light from them: with a Conjecture, proposed by Way of Query, and suggesting a Mean, by which their several Systems might be preserved from the Disorder and final Ruin, to which they seem liable by that Waste of Matter, and by the Law of Gravitation.*

By JAMES BOWDOIN, *Esquire,*
President of the American *Academy of Arts and Sciences.*

HAVING in a preceding memoir laid before the Academy the observations, that occurred on the subject of Dr. *Franklin's* hypothesis relative to light, I shall now consider his objections to the received doctrine concerning it.

The objections will appear by the following paragraph taken from one of his letters on philosophical subjects.

"I must own, says the Doctor,* I am much in the dark about light. I am not satisfied with the doctrine, that supposes particles of matter called light, continually driven off from the sun's surface, with a swiftness so prodigious! Must not the smallest particle conceivable have, with such a motion, a force exceeding that of a twenty-four pounder, discharged from a can-

IV

* See Letters and Papers on Philosophical Subjects. p. 264. edit. 1769.

Just as these memoirs were going to the press, an ingenious gentleman of the *American* Academy, favoured me with the Philosophical Transactions for 1770, (the 6oth vol.) in which the Rev. Dr. *Horsley*, in a paper entitled, "Difficulties in the *Newtonian* Theory of Light, considered and removed," quotes this passage from Dr. *Franklin's* letters; and very ingeniously discusses the questions contained in it.

The subject being considered in that paper, upon principles different from those adopted in this memoir, there will not be found any similitude between them.

non? Must not the sun diminish exceedingly by such a waste of matter? and the planets, instead of drawing nearer to him, as some have feared, recede to greater distances through the lessened attraction? Yet these particles, with this amazing motion, will not drive before them, or remove, the least and lightest dust they meet with: and the sun, for aught we know, continues of his ancient dimensions; and his attendants move in their ancient orbits."

The Doctor's dissatisfaction with the received doctrine, is founded on two objections implied in his queries, and which may be expressed in the following propositions.

1°. That, supposing the doctrine true, the smallest particle of light must be driven to us with prodigious force, a force exceeding that of a twenty-four pounder, discharged from a cannon. But this is contrary to fact.

2°. That the sun must be exceedingly diminished by such a waste of matter; and the planets, in consequence of it, must recede to greater distances from him. But, for aught we know, both the sun and the planets, continue in their ancient state.

From these propositions it is implicitly inferred, that the doctrine is not well founded.

Among the observations on the second proposition, an hypothesis will be proposed, by way of query, suggesting a mean, whereby the material system, collectively taken, might be preserved from the disorder and ruin, to which they seem liable from causes hinted at in that proposition.

In regard to the objection contained in the first proposition, it adopts the idea, that light, like any other body in motion, will strike with a force proportioned to the degree of its motion: which degree of motion, or the celerity, multiplied by the

the quantity of matter in the body, will, in the result, express its force or momentum.

If, then, we can suppose the quantity of matter in a particle of light to be, not indeed absolutely, but comparatively, 0, its momentum will also be comparatively 0; and it can have, in that case, no visible effect on the smallest particle of dust to remove it.

Let us now consider what reason there is for such a supposition. In order to that, I beg leave to introduce here, a paragraph from one of my letters to Dr. *Franklin*, printed with his letters and papers on philosophical subjects. It runs thus,* "The flame of a candle, it is said, may be seen four miles round. The light, diffused through this circle of eight miles diameter, was contained, before it left the candle, within a circle of half an inch diameter. If the density of light, in these circumstances, be as those circles to each other, that is, as the squares of their diameters (or, which is equivalent, if the density decreases as the square of the distance or semi-diameter increases) the candle-light, when come to the eye, will be 1027,709,337,600 times rarer than when it first quitted the half-inch circle. Now the aperture of the eye, through which the light passes, does not exceed one-tenth of an inch diameter, and the portion of the less circle, which corresponds to this small portion of the greater circle, must be proportionably, that is, 1027,709,337,600 times less than one-tenth of an inch: and yet this infinitely small point (if you will allow the expression) affords light enough to make it visible: or rather, affords light sufficient to affect the sight at that distance."

If

* Letters, &c. p. 275.

If the calculation, referred to in that paragraph, be just ; and we should suppose a single particle of light, though incomparably smaller, to be in bigness equal to that point, I would ask, whether the quantity of matter in such a particle would not be small in a greater degree than its velocity, equal to that of the sun's light, would be great ? If so, a particle of light in motion, agreeably to the foregoing supposition, may be here estimated 0, and its momentum not sufficient to remove the lightest dust ; much less to do as much execution as a twenty-four pounder, discharged from a cannon.

It is impossible to calculate the momentum, where the requisite data cannot be had : but supposing the candle-flame equal in bulk to a sphere of half an inch diameter, and to weigh as much as an equal bulk of air, viz. about one thirtieth part of a grain ; though in fact its gravity is incomputably less than that of air : then the square aforesaid will express the proportion, in which the density of the candle-light is diminished at the verge of the greater circle : and the same proportion of one thirtieth of a grain will express the weight of that light at the verge, viz. one 30,831,280,128,000th part of a grain ; which we will consider as the weight of a single particle of the sun's light. If the velocity of light be at the rate of 80,000,000 miles in six minutes, then its velocity will be 222,222 miles, equal to 14,079,985,920 inches, in a second. This number of inches, divided by 30,831,280,128,000, the supposed particles in a grain, will shew the degree of motion required in a body weighing one grain to give it a momentum, equal to that of a particle of light, upon the hypothesis assumed : which motion will be 456 millionth parts of an inch in a second, equal to one inch in 2190 seconds, or thirty six minutes and an half ; and is much slower

ſlower than the hour-hand of a common clock : which, with its greater degree of motion, and much greater quantity of matter, does not give to the ſmalleſt bodies, placed in its way, any viſible motion.

Preciſion in this calculation is not aimed at, and the nature of the ſubject does not admit of it : but it is apprehended, it will appear ſufficiently evident from it, that light, even if its velocity were much greater than it is, and its gravity equal to that of air, to which, with great diſadvantage to the argument, it has been, in that reſpect, compared, cannot drive before it the lighteſt duſt, or, indeed, give it any ſenſible motion at all.

To the ſame purpoſe it may be further obſerved, that light reflected to the eye through a microſcope and priſm, would, it is apprehended, exhibit the ſame variety of colours, as light coming directly from the ſun. In which caſe, the ray ſo viewed, (like the candle-ray, which has been conſidered as a ſingle particle only) muſt be compoſed of a multitude of particles ; and be a proof, that the particles of light are inconceivably ſmaller than the calculation ſuppoſes. This degree of ſmallneſs, however, repreſents them to be of great magnitude, compared with their real ſize : for when we conſider, that the ſun's light is diffuſed through the whole ſolar ſyſtem, and much beyond it ; and that a part of it, in that antenuated ſtate, is reflected to us from the planets, in which reflection it undergoes, by its divergence, a further, and an extreme, attenuation : and eſpecially when we conſider the immenſe ſphere, throughout which the light of the fixt ſtars is viſible, particularly thoſe of them, whoſe diſtance is ſo vaſt, that, at oppoſite points of the earth's orbit, they have no ſenſible parallax—the diviſibility of light, and the proportionable tenuity of its particles, confound the

the imagination; and render human calculation inadequate to express the precise degree of them, or the inconsiderableness of the momentum of those particles.

This inadequateness is particularly applicable to the foregoing calculation: which was purposely made on the disadvantageous principles assumed in it, to shew, that even on such principles, the momentum of light could produce no visible motion in the smallest bodies, that fall under our notice. But had the calculation been founded on the state of the sun's light reflected from one of the planets, for instance, the Georgium Sidus, lately discovered by Mr. *Herschell*, the result would have been widely different; and we should, in that case, have had a juster idea of the momentum. The light reflected to the earth from that planet, whose mean distance from the sun is said to be 5,000,000,000 miles, is so extremely attenuated, that the momentum of a particle of it, transferred to a body, weighing a millionth part of a grain, would communicate to it so small a degree of motion, that it would require millions of ages for that body to move the diminutive part of an inch mentioned in that calculation.

If these observations be just, it is apprehended they shew, with some degree of evidence, that a particle of light, notwithstanding its prodigious velocity, cannot by its impulse remove other bodies, or displace even the finest microscopic dust; and that the doctrine objected to, may be true, notwithstanding the the first of the two objections, which have been made to it.

The second proposition, containing the other objection, is, that in case there are particles of matter, called light, continually driven off from the sun's surface, the sun must be exceedi ngly diminished by such a waste of matter; and the planets,

nets, in consequence of it, must recede to greater distances from him, through the lessened attraction.

Here I beg leave to observe, that if the material system, in its present form, was not intended by its Creator to be perpetual, then the waste of the sun's matter, and the consequent disorder in the system, arising from the altered state of its gravitation, will only be a proof of that intention; and not operate against the truth of the doctrine.

That system, like every other, derived from the same original, doubtless has within itself the means of continuing in its present form, until the great and wise purposes of its Author shall be brought into effect, and compleatly answered.

With respect to the solar system, so far as its continuance depends on the sun, it seems calculated, notwithstanding the supposed waste of the sun's matter, to last for many ages: for the sun, by reason of its prodigious bulk, and the divisibility of its matter, must, from its own internal sources, furnish light to the system through a long tract of time, without being sensibly diminished. If those eccentric bodies, called comets, which have been thought intended to recruit the sun's waste of matter, do in fact answer that purpose, provision is then made for the preservation of the system, at least until those bodies shall have all successively fallen into the sun, and been expended. When that shall happen, if there be provided no further means of recruit, the system will begin to decay, and finally be reduced to a chaotic state: from which, like our earth, it may be restored in some new form, to answer the further purposes of the Creator. I mention our earth, as in the *Mosaic* account of it, its original is described in such a manner, as to give us the idea of its having been an old planet, by some means or other

reduced to a chaos ; from which it was renovated, and made suitable for the purposes, to which it has been applied.

There is nothing unreasonable, or improbable, in that idea : and if the earth was so renovated, it may be inferred from analogy, that in case the present system should go to decay, a new one, and perhaps a superior one, would arise from its ruins.

These observations are founded on the idea of the waste of the sun's matter, and its final dissolution, with that of the system depending upon it : whether gradually occasioned by that waste of matter, or more rapidly brought on by the general law of gravitation. In this view of things, the objection does not militate with the doctrine.

But perhaps it may be thought more philosophical, and that it would better comport with our ideas of the wisdom of the Creator to suppose, that when he created the system, he intended it should be a permanent one ; and at the same time furnished it with the means of its own preservation. In which case, may it not be further supposed, particularly with regard to the efflux of light from the sun, by which its matter is conceived to be wasted, that he provided means, whereby the effluent particles, after answering the purpose of their efflux, should be returned to the sun, to answer again, in a constant succession, the same purpose.

I do not know, whether the hypothesis, suggested in the following queries, and relative to that subject, be admissible, or not. It is however offered for consideration.

It was primarily and specially intended to suggest a mean for preventing the ruin, to which the material system seems liable from the general principle of gravitation : but the same mean may possibly be applied to restore to the sun, in a regular succession

cession, its effluent light; and thereby obviate the evil effects, that might otherwise follow from the efflux.

Is it not conceivable, that round the solar system, and the several systems, which compose the visible heavens, there might have been formed a hollow sphere, or orb, made of matter *sui generis*, or of matter like that of the planets, and surrounding the whole: having its inner or concave surface at a proper distance therefrom; beyond which surface light could not pass, and between which, and the particles of light, there should be a mutual repulsion? And might not the sun, or source of light, of each system, have been so placed, in respect of each other, and the concave surface of the surrounding orb, that there should be, by direct and repeatedly indirect reflections, an interchange of rays between them, in such a manner, as that to each there should be restored the quantity it had emitted; and thereby the waste of its matter be prevented: and this at the same time it dispensed its light to its particular system?

This use of such an orb is here meant to be considered as a secondary or incidental one; to which it might be applied: but the principal or primary use of it, as a counter-balance to the gravitating principle of the systems contained within it, will be seen in its proper place.

There is a remarkable phenomenon in the solar system, to which the ideal one, just mentioned, bears some resemblance, and by which it was suggested: I mean the ring or arch, which surrounds the planet Saturn. We are told by astronomers, that its width, and also its distance from Saturn, is about 25,000 miles;—forming around that planet a beautiful arch, which may be designed, among other purposes, to increase its light and heat, by reflecting upon it, like a concave mirror, the sun's

rays : of which, by reaſon of its great diſtance from the ſun, it would not otherwiſe have had a ſufficient quantity.

If Saturn were a luminous body *per ſe*, and the arch, (made of ſuitable matter, and properly conſtructed, for the purpoſe) entirely environed it, the whole quantity of light emitted from it, would be reflected back ; and no waſte of its matter ariſe from that emiſſion. The ſame kind of hollow ſphere or orb, ſurrounding, for inſtance, the ſolar ſyſtem, would anſwer the ſame purpoſe. Its ſun, being in the centre of the orb, would have all its light reverberated back to it : except the comparatively ſmall quantity intercepted by the planets : a great part of which quantity would, by direct, and indirect reflections, be returned to the ſun ; and a quantity equal to the remainder, by means of volcanoes, and other internal fires in the planets, might be thrown off from them, and conveyed to the ſun : whereby the equilibrium of the whole might be preſerved.

Such an orb for a ſingle ſyſtem appears ſimple and plain ; and ſuch an one for the whole choir of ſyſtems, though ſeemingly more complicated, might yet appear equally ſuitable for the purpoſe, when its ſtructure, and the laws and principles which governed it, and alſo the ſituation of the ſeveral ſyſtems relative to it, and to each other, ſhould become known.

Its ſtupendous extenſion would be no objection to the ſuppoſition of its reality : for if the convenience and pleaſure of the inhabitants of Saturn were a ſufficient reaſon for furniſhing that planet with its maſſy ring, the preſervation of ſuch a choir of ſyſtems, with the aſtoniſhing multitudes of their inhabitants, would juſtify and ſufficiently ſupport the ſuppoſition of ſuch an orb : eſpecially when it is conſidered, that beſides anſwering the grand purpoſe of preſerving thoſe ſyſtems, it might, per-

haps

haps like Saturn's ring, be provided on both sides of it, with ample means of making it a suitable place for habitation : the habitation of myriads of millions of animate beings, equal or superior to those, which people our planetary system.

Beyond that orb, at proper distances, it is conceivable, there might be other concentric orbs, equally suitable for habitation, and alike inhabited : including within them innumerable systems of planets, resembling the solar system, and like that animated, and adorning the infinite expanse.

To this hypothesis objections may be made, and such as might prove it to be, like many an one which has preceded it, a mere philosophical revery. But before it be ranked in that class, I would ask, whether, if there be no such orb, nor any thing to answer a like purpose, the law of gravitation, that universal law, on which the philosophy of the immortal *Newton* is founded ; by which, with such admirable sagacity, he has explained the phenomena of material nature ; and on which he makes its preservation depend, will not finally bring on its dissolution ? Or rather, whether the operation of that law would not long ago have brought it on ?

The sun of our planetary system, and the suns (called fixt stars) of other systems, and therefore the systems themselves, do probably, according to astronomical observations, possess the same relative place ; or are, in respect of each other, fixt. But how are the exterior systems (supposing the whole not boundless) prevented from approaching towards the common centre of gravity : from which, if they have no revolution round it, (which the like observations make probable) they cannot be kept by a projectile or centrifugal force ? Must they not constantly by that law be drawn, with an accelerating motion,

[illegible] ?

tion, towards that centre ; and finally, with the whole choir of systems, directed by that law, arrive at it with successive tremendous crashes, until the destruction of the whole would be compleated ? And could any thing but the interposition of the Power which created them, prevent it ?*

If such a catastrophè would be the effect of that law, would it not demonstrate the wisdom, and foresight of the Creator, to suppose, he provided the means of counteracting that effect at the same time he ordained the law ? And among the possible means of doing it, is it not conceivable, that a hollow sphere or orb, analogous to that above-described, might be one ?

It has been suggested in what way such an orb might prevent the gradual waste and decay of the material system. Let us now see, whether it might not be applied to prevent the swifter and more dreadful catastrophè, to which the law of gravitation, in certain circumstances, seems capable of subjecting that system.

The described orb, like every other body, would possess the gravitating principle, in proportion to its quantity of matter : which, in different parts of the orb, might be more or less dense, as the effect, intended to be produced, might require. Where a strong attractive power might be necessary, the density would be greater ; and so, *vice versâ :* and to assist or cooperate with it, a magnetic power might be superadded.

Thus

* Mr. *Whiston* observes, " It is by no means impossible, that all the bodies in the universe should approach to one another, and at last unite in the common centre of gravity of the entire system : nay, from the universality of the law of gravitation, and the finiteness of the world, in length of time, except a miraculous power interpose and prevent it, it must really happen." Discourse introductory to his Theory. p. 38.

Thus constituted, and furnished with those, and other needful qualities, and surrounding the whole visible choir of systems, might not the orb, by the principle of gravitation, either alone or assisted, keep those systems next to it, from being drawn towards the centre of gravity by their own, and the mutual action of the interior systems? And might not those several systems be so placed, and the densities of the bodies respectively belonging to them, with the densities of the surrounding orb, and consequently their mutual gravitating power, be so regulated, and adjusted, as to keep them all at the distance assigned them; and forever prevent their approximating, either to the centre of the general system, or to its surrounding orb: all of them together thus constituting an undecaying permanent whole?

It has been observed by philosophers, "that a body placed any where, within a hollow sphere, which is homogeneous, and every where of the same thickness, will have no gravity, wheresoever it be placed: the opposite gravities always precisely destroying each other."* But that observation cannot be applied to the hollow sphere or orb, above-described: for by the description, it is not homogeneous.—Nor need it be of equal thickness: which, however, is a circumstance of no consideration, if equal thickness, with different degrees of density in different parts, would answer the purpose.

The phenomena of nature, upon the supposition of such an orb, would probably be the same, *cæteris paribus*, as now take place. Whether that supposition be supported by phenomena, and what other foundation there is for it, will be the subject of a future memoir.

* *Chambers's* Cyclopædia, under the word Gravity.

III. *Observations tending to prove, by Phænomena and Scripture, the Existence of an Orb, which surrounds the whole visible material System; and which may be necessary to preserve it from the Ruin, to which, without such a Counterbalance, it seems liable by that universal Principle in Matter, Gravitation.*

By JAMES BOWDOIN, *Esquire,*
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AT the conclusion of a memoir, entitled, "Observations on Light, &c." which I have had the honour to lay before the Academy, it was intimated, that there are phenomena in nature, and other evidence, tending to prove the existence of an orb, that surrounds the whole visible material system.

The evidence is,—phenomena and scripture.

The phenomena are,—the luminous girdle in the blue expanse, called the Milky Way;—other luminous appearances in it; and the expanse itself.

In regard to the luminous girdle, or Milky Way.—This phenomenon has been supposed to result from the combined lustre of infinite multitudes of stars, too distant to be distinctly visible. But although it be observed through telescopes, that there is a great number of stars in the Milky Way, on which circumstance the supposition is founded, they appear as stars set in it; distinguishable from it; and not contributing to form the phenomenon.

The supposition not only disagrees with the appearance, but is inconsistent with every philosophical idea concerning those stars. They are represented to be suns: each having its system

tem of planets revolving round it; and consequently requiring a space proportioned to their number, and the extent of their systems: which space, for such multitudes of them as the supposition implies, must be beyond conception immense: and through which they must therefore be dispersed at such distances, that comparatively few of them could be visible by us; and that the whole together could not blend their light to cause that phenomenon.

On the contrary, the phenomenon strikes us, as it may be supposed such a luminous girdle would strike, if its light were reflected from the concave surface of a far distant orb: to which, on the hypothesis assumed, it had been propelled from the numerous systems, which the orb enfolds.

The same idea is suggested by the different degrees of its light, from a small light to a faint scarcely discernible one; by the frequent interruptions of it; and by the large chasm, which for a considerable space, makes the girdle appear double, and very irregular.

These appearances may be occasioned by the situation of the earth in respect to those parts of the orb, from which certain cones of light (presently to be explained) are reflected; and by the particular construction, and configuration of those parts; by means of which those cones are broken, and irregularly reflected to the earth: whose different situations in its orbit, by reason of its great distance from the orb, would occasion no sensible difference in the appearance.

With respect to the other luminous appearances in the concave expanse, I beg leave here to introduce several observations, upon that subject, from two authors, who have distinguished themselves in the astronomical branch of science.

One of them, Dr. *Smith*, in his System of Optics,* observes, that "*Hugenius*, in the year 1656, looking by chance through a large telescope, at three small stars, very close to one another, in the middle of Orion's Sword, saw several more as usual. But the three little stars very near one another, (marked θ by *Bayer)* together with four more, shone out as it were through *a whitish cloud, much brighter than the ambient sky:* which being very black, caused that lucid part to appear *like an aperture, which gave a prospect into a brighter region.* He viewed it many time, and found it continued in the very same place, and of the same shape as the figure represents; [See plate II. fig. 8.] and called it *Protentum cui certe simile aliud nusquam apud reliquas fixas potuit animadvertere.*"

He also observes, that "in the Philosophical Transactions,‡ there is an account of a later discovery of *five more such lucid spots*, though less considerable than this of *Hugenius*; *the middle* of which, we are there told, is at present in ♊. 19° 00′, with south latitude 28° 45′; and that it *sends forth a radiant beam* into the south-east, *as another* in the girdle of Andromeda *seems to do* into the north-east. It is also there remarked, that though these spots are in appearance but small, and most of them but a few minutes in diameter; yet, since they are among the fixt stars, as having no annual parallax, they cannot fail to occupy spaces immensely great; and, perhaps, not less than our whole solar system: *in all which spaces*, it should seem, that *there is a perpetual uninterrupted day.*"

nebulae

The

* P. 447—8.

No. 347 *Jones's* Abr. vol. iv. p. 224.

The other author, Mr. *Ferguſon*, ſpeaking of the Milky Way, ſays, † " There is a remarkable tract round the heavens, called *the Milky Way* from its peculiar whiteneſs, which was formerly thought to be owing to a vaſt number of very ſmall ſtars therein : but the teleſcope ſhews it to be quite otherwiſe ; and therefore *its whiteneſs muſt be owing to ſome other cauſe.* This tract appears ſingle in ſome parts, in others double."

" There are ſeveral little whitiſh ſpots in the heavens, which appear magnified, and more luminous, when ſeen through teleſcopes ; *yet without any ſtars in them.*" Five of which ſpots he particularly mentions.

He next obſerves, that " cloudy ſtars are ſo called from their miſty appearance. They look like *dim ſtars* to the naked eye : but through a teleſcope, they *appear broad illuminated parts of the ſky* ; in ſome of which is one ſtar, in others more.—But the moſt remarkable of all the cloudy ſtars, is that in the middle of Orion's Sword, where ſeven ſtars (of which, three are very cloſe together) ſeem to ſhine through *a cloud very lucid* near the middle, but faint and ill-defined about the edges. It looks like *a gap in the ſky*, through which one may ſee, as it were, *part of a much brighter region.*"

Theſe quotations, without making any comment upon them, ſhew, that the Milky Way is not owing to the ſtars contained in it ; that the teleſcope ſhews it to be quite otherwiſe ; and that it muſt be owing to ſome other cauſe : that in reſpect to the lucid ſpots, in ſome of them there are no ſtars ; in others but few ; and that one of them exhibits a remarkable appearance of an aperture, or gap, that gave a proſpect into a brighter region : that the ſpaces they occupy, though ſmall in appear-

† Aſtronomy. p. 339—40. Edit. 4th.

ance, are, perhaps, not lefs than our whole folar fyftem ; and that in them it fhould feem there is perpetual uninterrupted day.

From thefe phenomena it feems not improbable, that the Milky Way, and thofe lucid fpots, are parts of a concave body or orb, of the fame nature with fome of the other heavenly bodies ; and, whofe light, tranfmitted to us, exhibits thofe phenomena, according to the laws and circumftances, which regulate it.

There is another, and ftill more remarkable phenomenon, that fuggefts the idea of fuch an orb : I mean the blue concave expanfe, which furrounds, and appears to limit vifible nature ; and which is the laft to be confidered.

It is thus explained by Sir *Ifaac Newton* ; who obferves, " that all the vapours, when they begin to condenfe and coalefce into natural particles, become firft of fuch a bignefs as to reflect the azure rays, ere they can conftitute *clouds* of any other colour. This, therefore, being the firft colour they begin to reflect, muft be that of the fineft and moft tranfparent fkies : in which the vapours are not arrived to a groffnefs fufficient to reflect other colours."*

By this explanation it appears, that the caufe of this phenomenon exifts within the earth's atmofphere. If it really doth exift within it, the phenomenon, from the affigned caufe of it, feems to be nothing more than a blue tranfparent cloud, more or lefs extenfive, in proportion as the atmofphere may happen to be lefs or more charged with other clouds.

If this were the caufe, would not the heavenly bodies, in a clear fky, partake of the colour of that cloud, and appear blue, or be tinged with it, by means of their light paffing through the

* *Chambers's* Cyclopædia, under the word Bluenefs.

the blue cloud? And would not this appearance indicate, that the blue rays of their light were tranſmitted, and the other coloured rays, for the moſt part, reflected from the atmoſphere? Would not that tranſmiſſion of the blue rays occaſion all bodies around us to appear blue, ſo long as the atmoſphere, continuing clear, ſhould exhibit the blue cloud? And would not the colours of thoſe bodies vary as other coloured clouds ſhould ſucceed and predominate?

Would not this reflection of the other coloured rays occaſion, not only a decreaſe of light, but, with reſpect to the ſun, a great diminution of its heat? If the ſeveral different coloured rays do each, in reſpect to heat, produce an equal effect; and all but the blue rays are reflected, ſhould we not, in a clear day, be deprived of ſix ſevenths, or a proportionable part, of the ſun's heat, which the ſeven ſorts of rays, had they been all tranſmitted, would have afforded?

Such appearances and effects might have been expected, if the aſſigned cauſe produced the phenomenon: for the ſun's light and other light; and alſo bodies in general, whatever be their colour, being viewed through a medium of any original colour, will appear of that colour, or ſtrongly tinged with it. But it is apprehended, that no ſuch appearances and effects have ever been obſerved; and, therefore, that there is reaſon to doubt the reality of the cauſe aſſigned: the inſufficiency of which may further appear in the courſe of theſe obſervations.

But how is the exiſtence of the orb deduced from the phenomenon?—In the ſame manner as the exiſtence of the other heavenly bodies, and the exiſtence of the bodies around us are deduced: namely, from the uniformity and permanency of their viſible qualities, or phenomena.

In

In regard to bodies around us, whenever by ſight we have been impreſſed with certain ideas of colour, form, and magnitude, correſponding to bodies near us, and at an approachable diſtance, we have found, by conſtant and uniform experience, derived alſo from, and confirmed by, every other ſenſe and means of information, that ſuch bodies do really exiſt : and having thus from experience gained the knowledge, that certain phenomena do infallibly indicate the exiſtence of thoſe bodies, the phenomena themſelves do then alone become the undiſputed evidence of that exiſtence.

Nature is ſimple and uniform in its operations. From the ſame cauſe follow like effects ; and theſe indicate the ſame cauſe. Bodies of every kind, through the medium of light, produce their reſpective phenomena, and theſe demonſtrate the reality of thoſe bodies.

From theſe principles we infer the reality of thoſe terreſtrial bodies, which, by reaſon of their ſituation and diſtance, can only be the objects of ſight : and from the ſame principles we alſo infer the reality of the heavenly bodies, the planets, and fixt ſtars. If this laſt inference be juſt, is it not equally juſt to infer, from the ſame principles, the reality of the blue circumambient expanſe : that is, that it is a real concave body, encompaſſing all viſible nature : which is the exact deſcription of the concave ſurface of the orb above-mentioned.

There is one appearance of the blue expanſe, which may be thought to militate with the foregoing account of it.

In a clear day, it appears of a brighter blue than in the night, occaſioned by the ſun's light reflected to us by the earth's atmoſphere. From which circumſtance it might be ſuppoſed, that the cauſe of the phenomenon doth exiſt within the atmoſphere,

phere, and is the atmosphere itself, or its vapour. It is apprehended, however, that this would be a mistaken supposition; and that the appearance may be explained on principles, which will not only invalidate the supposition, but further shew the insufficiency of the cause, to which the phenomenon has been ascribed.

For that purpose it may be observed, that the atmosphere being invisible, must be without colour; and has, perhaps for that reason, no greater disposition to transmit or reflect to us the blue rays of light, whether of the sun or stars, than those of the other colours: and, therefore, if the phenomenon be produced by means of the blue rays of those luminaries (which I shall attempt to explain) the atmosphere cannot be the cause of that production.

With respect to the vapours in the atmosphere, which, in a particular state, are said to occasion the phenomenon, they being of different degrees of grossness or density, must arrange themselves according to that density, or their specific gravity. If then any of the ranges consisted of vapour, in a proper state to transmit or reflect to the eye the blue rays only, the effect of it would be destroyed, or changed, by the grosser vapour in the lower range. Or if it should so happen (which seems very improbable) that the whole body of vapour should consist of particles of the due size, and in the proper state, to reflect the blue rays, it could not long continue in that state, by reason of the changeable nature of the vapour, and the numerous causes, that are constantly operating to produce a change in it. But the phenomenon is uniform and premanent; and therefore must be the effect of an uniform and permanent cause.

If

If these observations have any foundation, neither the atmosphere nor its vapour, assisted by, or assisting, the *direct* light of the sun and stars, can be the cause of the phenomenon.

The atmosphere, however, or its finer and transparent vapour, contributes to the brighter hue of the phenomenon by day: which may be thus explained.

The sun's light in its mixt state, reflected by the atmosphere, or by the transparent vapour floating in it, enters the eye at the same time with the blue light of the expanse; and both together delineate on the retina an image, formed by their united rays, each producing its effect. The light from the expanse exhibiting the blue image; the light from the sun illuminating or brightening the image; and both together impressing the idea of that phenomenon, as it is displayed in a clear day.

If it should be asked, from whence the concave expanse derives its light, the answer is—from the numberless planetary or solar systems, which it includes: and particularly from those in the neighbourhood of it, which directly answer the purpose of enlightening, and in other respects, accommodating its inhabitants.

This light, transmitted to the expanse through its atmosphere, is reflected back directly and indirectly to the systems from which it issued: to be again, in a due succession, remitted to, and reflected from, the expanse. By such a reciprocation, and mutual interchange of light with each other, and among themselves, the several parts may be supplied with the quantity they had respectively emitted; and the equilibrium of the whole maintained: whereby the evils, that might otherwise ensue, from the waste, or undue distribution of its matter, and the consequent alteration of its gravitation, might be prevented.

To

To different systems, according to their situations, the expanse may exhibit very different phenomena. Although to our system, or to us on this planet, it exhibits the blue concave of an all-surrounding orb; which, in the Milky Way, and in some other parts of it, shines with a brighter light, it may to other systems appear of other colours; and exhibit to some of them in succession, according to their situations, the several primitive colours in the order, in which the rays of those colours are separated and classed.

Of one of these exhibitions, that of the blue colour, we have ocular demonstration. But why should the expanse appear to us blue, rather than green, or of any other primitive colour? If that appearance can be explained by the refrangibility of light, or by the separation of it into its several colours, as perhaps it can, the other appearances of the expanse to other systems, naturally, if not necessarily, follow.

Experiments prove, that light is compounded of differently coloured rays; and that after it has past through different mediums properly dispos'd, the rays are refracted, or separated and classed, according to their different refrangibility; and shew those colours in the order just mentioned: that the three most refrangible of them, the blue, the indigo, and violet, which possess one half of the space spread over by the whole, are so nearly allied in colour, that the last, when considerably spread, are scarcely to be distinguished from the neighbouring blue: for which reason, those three classes appear as one, at a great distance from the refracting medium: and the blue thus circumstanced, and uniting those classes, may therefore be said to possess a space equal to the space occupied by all the rest. That from any segment of a hollow sphere, such, for instance, as a

 concave

concave mirror, whose arc does not exceed fifteen or eighteen* degrees; the cylinder of rays falling upon it parallel to its axis, will, if there be no refraction, be reflected to a focus round that axis: the focus being nearly equidistant from the pole of the segment, and the centre of its sphere: and that those rays, if previously refracted, and classed into their several colours, will, in their divergence from the focal point, shew those colours in a reversed order: the refraction, however, occasioning an alteration in the position of the focus, and the diverging cone.

To apply some of these observations, it may be supposed, that the interior side of the expanse has, in general, an uniform surface, which may be conceived as composed of a multitude of segments, each of them not exceeding a given arch: that it is furnished with an atmosphere, possessing, in some peculiar mode, the power of refracting light, of distributing its rays into their respective classes, and transmitting them to the expanse; which also may be conceived as assisting, by its reflecting power, in their classification: that the transmitted rays would, in their classed state, be reflected from it in all directions; and that such of them (by far the greatest † part of the whole) as should come

* 's *Gravesande's* Natural Philosophy. Book III. ch. xv. prop. 813.

† That these parallel rays (parallel, I mean, to any and every conceivable diameter-line of the expanse) must constitute the greatest quantity or proportion of the reflected light, will be manifest from these considerations:—That they come to every segment or part of the expanse from the opposite part of it, and from the systems situated between such opposite parts: that the distance of any two opposite parts from each other, equal to the diameter of the expanse, is the greatest that can take place within it: that there must, therefore, be, in the space between them, a greater number of systems supplying the expanse with light, than there can be in any

come to the atmosphere in parallel lines, or in cylinders, whose axes were diameter-lines of the expanse, and whose bases were equal to those segments, would pass through the atmosphere to the corresponding segments of the expanse, and be reflected from them; and afterwards, in the same classed state, unite in a focus, from which they would diverge, and exhibit their several colours.

To give some idea, though an imperfect one, of that focus, the reflection and convergence may be conceived as made (somewhat in the manner above-represented) from the segments composing the whole surface of the expanse: that each segment would reflect a cone of rays, terminating in a focus; and that the united *foci* of those cones, which must be considered as coming from all quarters of the expanse, would constitue its general focus.

In some such disposition, and state of things, as here represented, it is conceivable, that the system-light, transmitted to the expanse through its atmosphere, might be reflected from those segments; and for the most part converge in cones towards a general focus: where, by means of the refraction and separation, it had undergone in that transmission and reflection, it would be, in each cone, arranged or classed, according to the different refrangibility and reflexibility of its rays. After the rays had past the boundary of their focus, they would intersect each other, and form new and reversed cones, or conic

 figures:

any extra-central direction; and that this may be affirmed of every two opposite parts or segments in the whole surface of the expanse. The effect of the atmosphere, in regard to the refraction, is not here noticed. These rays, like the sun's rays at the earth, are considered as parallel, by reason of the great distance of the radiant bodies, and the consequent extreme minuteness of the angle of divergence at such a distance.

figures: in which each ſort of the coloured rays, as before the interſection, would generally be together; and in that aſſociated ſtate, continually diverge in proportion to their diſtance from the line of interſection.

But perhaps the whole of this effect, the claſſification of the rays, may be cauſed by the reflecting power of the expanſe: which, in that caſe, would receive the rays in the ſame mixt ſtate as the direct ſolar light comes to the earth: with reſpect to which, we know that it frequently undergoes a claſſification by reflection, as well as by refraction.

In either caſe, as the three moſt refrangible, and reflexible claſſes, at a proper diſtance from the focus, are not to be diſtinguiſhed from each other, but all appear blue: and as the blue, at that diſtance and beyond it, doth therefore poſſeſs ſo large a portion of the interior ſpace of the expanſe, it is conceivable, that many ſyſtems may be ſo placed, as to be on all ſides in the direction of the rays of that colour; and to which the whole expanſe would, for that reaſon, appear blue.

With reſpect to the earth, it is probably ſo ſituated as to be in all parts of its orbit, principally within the limits of ſuch claſſes as are compoſed of the blue rays; and partly within the verge of claſſes, whoſe rays, by reaſon of their imperfect ſeparation being in a mixed ſtate, exhibit a brighter light. The predominant colour, therefore, of the expanſe, as it reſpects the earth, is blue; with interſperſions of a brighter light, ſuch as the Milky Way, and other lucid parts of the expanſe: whoſe irregular appearance, in the Milky Way, may be owing (as hath been already ſuggeſted) to the particular conſtruction and configuration of its parts: the brightneſs of which ſeems to

intimate

intimate ſome peculiarity in their conſtitution, and in the circumſtances attending them.

Nature thus exhibiting, on a broad ſcale, phenomena, which our little experiments can exhibit only in miniature; and of which thoſe experiments ſometimes lead to a happy explanation.

Whether the foregoing be ſuch an explanation, or wholly chimerical, in reference to the colour of the expanſe, does not affect the expanſe itſelf: whoſe exiſtence, conſidered as an all-ſurrounding orb, may be real, although the aſſigned cauſe of its colour be demonſtrably without foundation.

From the ſeveral phenomena above-mentioned, unleſs the evidence ſuppoſed to ariſe from them be futile, or inadmiſſible, there is reaſon to conclude, that an all-ſurrounding orb doth really exiſt; and that the blue expanſe is that orb.

It is an obſervation of Sir *Iſaac Newton*, "that the main buſineſs of natural philoſophy, is to argue from phenomena, without feigning hypotheſes; and to deduce cauſes from effects, till we come to the very firſt cauſe, which certainly is not mechanical; and not only to unfold the mechaniſm of the world, but chiefly [among others that are mentioned] to reſolve theſe, and ſuch like queſtions, viz. Whence is it, that the ſun and planets gravitate towards one another, without denſe matter between them? and what hinders the fixt ſtars from falling upon one another?*

Agreeably to the foregoing obſervation, the author of this memoir having adduced certain phenomena, he hopes not impertinently, has endeavoured, not only to argue from them, and to deduce the cauſe from the effects, but to reſolve that great queſtion

* Opticks. p. 344. 4th edit. 8vo.

queftion concerning the fixt ftars, and the heavenly bodies in general, namely, What hinders them from falling upon one another, and thereby involving the whole in ruin ?—Whether his endeavours have been fuccefsfully applied, thofe who are converfant in fubjects of this nature, are beft qualified to judge.

In regard to the fubject in hand, there feems to be a happy co-incidence between phenomena and fcripture ; and, therefore, in further evidence of fuch an orb, and in evidence of feveral other orbs fimilar, and concentric to it, we may recur to fcripture : feveral paffages of which appear applicable to that purpofe.

It feldom happens that natural philofophy is made to borrow affiftance from thence : but though fcripture may not be intended to inftruct us in the philofophy of material nature, it may neverthelefs give, and be intended to give, fome hints of its conftitution, or general fyftem.

As the paffages referred to, do not need any laboured comments, a very few obfervations will fuffice to explain and apply them.

A remarkable one, and which may ferve, in fome meafure, to elucidate the reft, is this paffage, " It is GOD that buildeth his ftories in the heavens."* In the *Englifh* tranflation, which agrees with the *French*, with the *Latin* of *Caftellio*, and of *Tremellius* and *Junius*, the marginal reading, referring to ftories, is fpheres and afcenfions. The former explanatory of ftories : the latter, another word for the *Hebrew ;* and which anfwers to the *Greek* of the *Septuagint*. All which, both feparately and together, give the idea of a fucceffion of concentric fpheres, afcending one above another, like the ftories of a magnificent building :

* *Amos*, ch. ix. 6.

building: and, agreeably to that idea, though on very different principles, perhaps thoſe of the *Ptolemeian* ſyſtem, the text has been explained.*

This conſtruction, which appears to be a natural one, gives a meaning to the text,—a meaning illuſtrative of the omnipotence of the Architect: and, at the ſame time it elucidates ſome other texts relative to the ſubject, it is perfectly deſcriptive of the concentric ſpheres, or orbs, above-mentioned.

The ſame idea is intimated in the ſhort account given of the creation by *Moſes*, who ſeems to refer to two firmaments.—The firſt he mentions is limited to the earth and its atmoſphere; and the other is that in which the fixt ſtars do appear.

It is this latter, that is here to be conſidered: concerning which, "God ſaid, let there be lights in the firmament of heaven;" and concerning which it is declared, that "God ſet thoſe lights in the firmament."‖

The radix of the *Hebrew* word, tranſlated firmament, "is applied to God's ſpreading out the ſky; to the firmament, or ſpacious

* Qui ædificat in coelo (in ſupremis cœlis) aſcentiones ſuas—ſphæras ſuas—gradus ſuos: i. e. orbes coeleſtes, qui ſunt velut gradus; unus ſupra alterum.

Poli ſynopſis in loc.

‖ Gen. ch. i. v. 14. 17.

Mr. *Whiſton*, whoſe explanation of the *Moſaic* account of the creation is natural, and in general ſeems to be juſt, makes no diſtinction of firmaments: which, however, he might have made, without injuring his theory; and which his own rules of interpretation would have juſtified.

The upper firmament, or blue expanſe, in which the heavenly bodies were "ſet," he might have included, together with them, in the work of the fourth day, or year, as it was rendered viſible at the ſame time, by means of the earth's atmoſphere, in that year, becoming tranſparent: which atmoſphere, according to his theory, is the [other] firmament, or expanſe. He ſuppoſes, the earth had no rotation about its axis until the deluge; and, therefore, that its annual revolution round the ſun, would occaſion the antediluvian day to be exactly commenſurate with the year.

ſpacious extenſion, which is ſpread abroad between the earth and the clouds : *as alſo to that other* firmament, or ſpacious extenſion, which is above the clouds, where the heavenly bodies are placed."*

The original word † means, not only firmament, but expanſe, or ſpacious extenſion. In the *Engliſh* tranſlation, and alſo in the *Greek* of the *Septuagint*, it conveys the idea of ſomething firm and ſolid. Some other tranſlations adopt the other acception of it. It ſeems to include both ; and in that caſe means ſomething ſolid, and ſpaciouſly extended.

This explication of the term, connected with the appearance of this firmament, or expanſe, gives us the intimation of a ſolid and ſpaciouſly extended orb, or ſphere : and anſwers to one of the ſtories, which God built in the heavens.

" The heavens ‡ declare the glory of God : and the firmament ſheweth his handy-work."—Here is a clear diſtinction between the heavens and the firmament. By the former, are meant the heavenly bodies ; and by the latter, the firmament, or expanſe, in which they appear.

The ſame obſervations may be applied to this, as have been applied to the foregoing paſſage.

Another, and more deſcriptive of ſuch an orb, is the following one : " Haſt thou ſpread out the ſky : which is ſtrong, and as a molten looking-glaſs :"‖ or, as a mirror made of poliſhed

* *Taylor's Hebrew* Concordance, root 1826.

† The author of this memoir, being unacquainted with *Hebrew*, ſpeaks of its meaning by information only.

‡ Pſalm xix. 1. Cœlum hoc ſtelliferum. Poli Syn.

‖ *Job* xxxvii. 18. An expandiſti cum eo (eum adjuvando) æthera, vel cœlos, vel firmamentum ? Hoc græci vocant ſtereōmà quod—firmum ſit, et ſuâ ſe velut virtute

lished metal. The forementioned *French* and *Latin* versions, and the *Greek* of the *Septuagint*, do, in this passage, all concur with the *English*, in representing the sky as strong, firm, and solid. The *Septuagint* especially, expresses this idea with peculiar force; as doth also the *Hebrew* original: which, in this place, resembles the sky to a *speculum*, or mirror, "made of polished metal."*

"The elegant simile of the mirror cannot be understood without recollecting, that their looking-glasses (or mirrors) were made of metal highly polished."†

This description shews the sky to be, not only firm and solid, but remarkably adapted to reflect light; and so far intimates the cause, why it is visible. The sky here, as the firmament in a former clause, corresponds to one of the stories, which God built in the heavens.

There are other passages, which mention the spreading out, and stretching out, of the heavens; and this as declarative of the discretion, the understanding, the wisdom, and power of God. But if it be a mere appearance, arising from the atmosphere-vapours, in a particular state reflecting to us the blue rays of light; or if it be a mere circumstance attendant on, or resulting from, the atmosphere; and doth not indicate the real ex-

E e istence

virtute contineat, nullâ re nitens. Æthera, vel cœlos—quì solidissimi—quì sunt fortes: item sicut speculum fusum, sive concretum.—Cœlos, quibus *firmitas* tribuitur Prov. viii. 28. unde poetæ cœlum vocârunt kalkeon ouranon. Specula fusa intellige ex ære vel chalybe.—Vox *fortes* soliditatem denotat.—Cœlum,—solidissimum ut simul cohæreat. Poli Syn.

* Fusum, firmum, validum, instar fusi et consistentis metalli. *Taylor's Hebrew* Concordance, root 783. 26.

† *Scott's* Book of *Job*, p. 354.

iſtence of what is declared to be thus ſpread or ſtretched out, it is then, in a comparative view, but an inferior inſtance of wiſdom and power: by no means ſuch an inſtance of them as to entitle it to be mentioned in the climax, in which it is found: much leſs to be the head, or principal member, of it.

The following, which is one of thoſe paſſages, and in the ſenſe of which the aforenamed verſions concur with the *Engliſh*, will ſhew the climax.——"He hath made the earth by his power: he hath eſtabliſhed the world by his wiſdom; and hath ſtretched out the heavens by his underſtanding."*—The earth, including its atmoſphere—the world, or heavenly bodies collectively—the ſtretched-out heavens, or blue expanſe. This remarkable climax, aſcending in dignity and importance, ſhews, that the laſt and principal member of it, the expanſe, is not only diſtinct from the earth, and the whole ſyſtem of heavenly bodies, but that it ſurpaſſes them in excellence; and that it is the capital, among the works of the viſible creation. The deſcription of it, and its rank in the climax, indicate, that it is the ſame firmament or expanſe, above deſcribed; that the ſame obſervations are applicable to it; and therefore, that this, and the parallel paſſages alluded to, may be adduced in further evidence of its exiſtence; and, conſequently, of the exiſtence of an all-ſurrounding orb.

The ſame idea is held forth in a part of the addreſs of wiſdom in Prov. viii. 27—29: the ſenſe of which may be expreſſed in the following tranſlation; which differs from the common *Engliſh* tranſlation, no further than the apprehended ſenſe of the text makes neceſſary. A few explanatory notes are interſperſed, by way of illuſtration.

Wiſdom

* *Jer.* ch. li. 15.

Wiſdom ſpeaking, ſays,—verſe 27. " When God prepared the heavens [the whole ſyſtem of viſible nature] I was preſent. When (with reſpect to the heaven) he ſet an orb around the ſuperficies of the depth [the immenſe ſpace included within the orb : in reference to which, that ſpace may be juſtly called the depth] : v. 28. When he gave ſolidity and ſtrength to (that orb) the ſky above ; and when he eſtabliſhed its fountains of waters [its interior and exterior atmoſphers] : v. 29. When (with reſpect to the terraqueous globe) he gave to the ſea his decree, that its waters ſhould not paſs their bounds : and when he appointed the foundations of the earth, then I was by him."

If this tranſlation and illuſtration, be juſt, the text, which only gives the great out-lines, or capital parts of creation, ſtrongly impreſſes the idea, that there is an orb ſurrounding all viſible nature ; that it is ſtrong and ſolid ; and that it is furniſhed with an interior and exterior atmoſphere : all which is further deſcriptive of one of the ſtories, that God built in the heavens.

In ſupport of the tranſlation and illuſtration here given, I had collected, in a marginal note, a number of authorities from *Pool's* Synopſis : but it being ſomewhat long, and thoſe who are qualified to judge in the matter, being able to recur to the Synopſis, it is omitted.

Beſide thoſe authorities, and in further ſupport of the tranſlation, may be adduced the 148th pſalm : where are enumerated, in a regular ſucceſſion, the heavenly bodies, which compoſe the material ſyſtem :—the ſun, moon, ſtars, heavens, and waters above the heavens.

The diſtinct notice there taken of thoſe bodies, and the arrangement of them according to nature, make it probable, that by the heavens (in that paſſage, as in ſome others) are intended the orbs, that have been deſcribed. And, in regard to the waters above the heavens, they do plainly intimate, that thoſe orbs are each, like the earth, environed by an atmoſphere repleniſhed with waters, to anſwer the ſame purpoſes with the atmoſpheric waters of the earth.—Of that paſſage, there will preſently be occaſion to take ſome further notice.

If ſome happy genius, well verſed in *Hebrew*, and the philoſophy of nature, would arrange in due order, and faithfully tranſlate, thoſe parts of ſcripture, that in any reſpect refer to the conſtitution and economy of nature, and this with a view of reconciling them to nature, we ſhould probably find, that ſcripture philoſophy and natural philoſophy would mutually illuſtrate each other. Such a tranſlation and illuſtration would be a real acquiſition to ſcience; and might lead to diſcoveries, of which, at preſent, we can form no idea.

One quotation more, amidſt a further number that might be offered, will cloſe the evidence.

"The heaven, and the heaven of heavens, and the earth alſo, are the Lord's." "Thou haſt made heaven, the heaven of heavens, with all their hoſts: the earth, and the ſeas, and all things in them." "Praiſe him, ye ſun and moon, ye ſtars, ye heavens of heavens, and ye waters above the heavens."*

There are other paſſages of like import: but theſe containing all the varieties of expreſſion I have obſerved concerning the material heavens, or ſyſtem of nature, may be thought ſufficient.

That

* Deut. x. 14. *Neh.* ix. 6. Pſ. cxlviii. 3, 4.

That the material heavens are here intended, there can be no room to doubt, as they are mentioned in connection with the earth—with their hoſts—with the earth and ſeas, and the things contained in them—with the ſun, moon and ſtars—and with the waters above the heavens. They are evidently conſidered here as forming, in conjunction with thoſe other bodies, one vaſt ſyſtem; whoſe ſeveral conſtituent parts are, in the laſt clauſe of the quoted text, ranged in the order, in which it is natural to ſpeak of them; and in which, reckoning from the centre of our ſolar ſyſtem, they do in reality exiſt.

Here is a plain deſcrimination between the heaven; the heaven of heavens; and the heavens of heavens: which muſt imply ſome eſſential difference between them. To ſuppoſe the contrary is to confound language, and involve it in uncertainty. It would be to ſuppoſe thoſe expreſſions void of meaning; and would be treating ſcripture with the indecency, to which no other book, appearing to be dictated merely by common ſenſe, would be entitled. Thoſe expreſſions, then, neceſſarily imply ſome eſſential difference in the objects of them: and what that difference is, the quotation from *Amos* points out. The gradation, reſpecting the heavens, is remarkable; and without recurring to any thing elſe, ſuggeſts the idea of ſtories in them, orb beyond orb, as above explained. The ſeries too, in which they are mentioned—the ſun, moon, ſtars, heavens, and waters above the heavens—and the place they hold in the ſeries, ſuggeſt the ſame idea: which is ſtrengthened and confirmed by the expreſs declaration, that in fact there were ſuch ſtories built by the Almighty: or, as it is otherwiſe expreſſed, that "he made them with all their hoſts."

The

The laſt member of the ſeries is the waters above the heavens. Theſe waters, arguing from analogy, ſeem to indicate, and to be deſcriptive of atmoſpheres, that ſurround thoſe orbs, amply provided, like our atmoſphere, with waters, and other elements, proper for the ſupport of animal and vegetable life; and for other important purpoſes.

The number of thoſe ſtories, or concentric orbs, ſeems indefinite. The gradation clearly denotes a plurality of them: each having its hoſts—its ſuns and planets, or ſyſtems. The ample ſpaces between them, like the ſpace infolded by the orb, to which we more immediately belong, are beautified by thoſe glorious bodies, which, within each of the orbs, conſtitute ſyſtems innumerable, ſerving the like noble purpoſes, which our ſolar ſyſtem is calculated to ſerve, and doth ſerve.

The foregoing paſſages of ſcripture thus interpreted, appear to agree, in their reſult, with the phenomena above-mentioned; and, like them, to be naturally, and without force, applicable to the purpoſe, for which they were produced. Such agreement, it is apprehended, ſhews the propriety and fitneſs of the interpretation: as, on the other hand, a diſagreement with phenomena would prove the unfitneſs or falſity of any interpretation; and manifeſt it to be totally inadmiſſible.

When ſcripture and phenomena thus agree, they mutually elucidate each other; and, in that caſe, what is deducible from the one, is confirmed by the other. As, therefore, thoſe paſſages agree with the phenomena, they both together corroborate the evidence, which each afforded ſeparately, of the exiſtence of an interior orb.

With reſpect to the exterior orbs, the evidence for them muſt reſt on ſcripture. There can be no phenomena, from which

which to deduce their reality: unleſs the aperture, or gap aforementioned, with what it diſcloſes, be admitted as ſuch.

The phenomena, exhibited through that aperture, are indeed remarkable; and may indicate an exterior orb, or the bright region between that, and the orb, which more immediately ſurrounds us: in which bright region, as well as in ſome other of the lucid ſpaces in the expanſe, there ſeems to be an uninterrupted and perpetual day.

If in fact there be ſuch an aperture, the ſame appearances with thoſe, from which it was deduced, may indicate other apertures in the other lucid ſpaces, and in the Milky Way: for the aſcertaining of which, the obſervations of the ingenious Mr. *Herſchell*, with his largeſt magnifiers, ſhould he think proper to apply them for that purpoſe, might happily conduce.

Among the purpoſes, for which thoſe apertures were intended, if they really exiſt, this may be one,—to give to the *intra-orbic* and *tranſ-orbic* ſyſtems ſome intimation of each other, and of their mutual relation; and to afford them a glimpſe of the grand complicated ſyſtem, of which they are parts.

The immenſity of thoſe orbs doth not invalidate their exiſtence: on the contrary, immenſity is ſo congenial to our ideas of the Creator, and his works, that it affords, as applied to thoſe orbs, an internal preſumptive proof of their reality.

On the ſuppoſition of their exiſtence, what an aſſemblage of glorious bodies do they exhibit! peopled by an unlimited variety of beings, and arranged in a gradation beautiful and aſtoniſhing! Trace the gradation from the ſmaller to the larger planets, circling around their ſun, and with him forming a magnificent ſyſtem! Trace it from that ſyſtem, through ſucceſſive ſyſtems, to their ſurrounding orb! Trace it from orb to

orb,

orb, and through their ſeveral hoſts of ſyſtems up to the ſuperior orb, and its ambient atmoſphere ! Trace it in every poſſible direction, from the common centre to the utmoſt verge of that atmoſphere, and the moſt wonderful phenomena, in a rapture-inſpiring ſucceſſion, ſtrike the mental eye ! impreſſing the idea of a complete whole, ſelf-balanced, and held in union by univerſal gravitation ! exhibiting a ſuperlatively grand ſyſtem of ſyſtems, emboſomed in the infinite, all-comprehending eſſence of the Creator !

Grand and magnificent as this ſyſtem is, there may be another incomparably more ſo ; compoſed of myriads of ſuch ſyſtems, governed by the ſame laws, and with it ſurrounded by an immenſe orb, to counter-balance the gravitation of the included ſyſtems.

That other ſyſtem may be a part of a ſtill more ſplendid one, formed on the ſame plan ; and this latter may enter into the compoſition of other ſyſtems, beyond compariſon ſuperior to it : each ſucceeding ſyſtem, in a regular progreſſion, riſing in dignity and ſplendour. And thus we may go on, enlarging our idea of thoſe ſyſtems, indefinitely.

What is there to check that idea, when we conſider the infinity of ſpace, in connection with the infinite wiſdom, power and benevolence of the Author of nature ; and at the ſame time reflect, that infinite ſpace is the proper, and the only adequate theatre for the diſplay of thoſe perfections, and of ſuch a character ?

This hypotheſis, by introducing ſolid orbs, may poſſibly, on a ſuperficial view of it, be thought a revival of the ancient or *Ptolymeian* Syſtem, and to grow out of it. But on the contrary, it will be found, upon examination, totally inconſiſtent

with

with it; and to be in reality the offspring of the new philoſo-phy: derived from the grand principle of that philoſophy—univerſal gravitation.

Upon the whole:—The hypotheſis, ſo far as it relates to the exiſtence of the interior orb, immediately ſurrounding the viſible heavens, the author of it apprehends to be a probable deduction from the principle of gravitation; and to be deducible alſo from phenomena and ſcripture. He offers it for conſideration, with the hope, that if it ſhould appear not wholly groundleſs, it may be productive of a happier illuſtration.

IV. *An Account of a very uncommon Darkneſs in the States of* New-England, *May* 19, 1780. *By* SAMUEL WILLIAMS, *A. M. Hollis Profeſſor of Mathematics and Philoſophy in the Univerſity at* Cambridge.

THE beſt method to promote the knowledge and ſcience of nature, is to proceed by way of obſervation and experiment. The general courſe, productions, and laws of nature, ſhould be carefully and ſteadily attended to: and when any new phenomena appear, all the circumſtances and effects, relating to them, ſhould be particularly noted and collected. In this way we ſhall be moſt likely to arrive at the knowledge of their cauſes: or, at leaſt, we ſhall prepare thoſe materials which may enable poſterity to determine, with certainty and preciſion, on what at preſent may be but imperfectly underſtood.

With this view, I ſhall endeavour to lay before the Society, as particular an account as I can collect, of the uncommon darkneſs which took place in the ſtates of *New-England*.

The *time* of this extraordinary darkneſs, was May 19, 1780. It came on between the hours of ten and eleven, A. M. and continued until the middle of the next night; but with different appearances at different places. As to the *manner* of its approach it ſeemed to appear firſt of all in the S. W. The wind came from that quarter, and the darkneſs appeared to come on with the clouds that came in that direction. The *degree* to which the darkneſs aroſe, was different in different places. In moſt parts of the country it was ſo great, that people were unable to read common print—determine the time of day by their clocks,

clocks or watches—dine—or manage their domeſtic buſineſs, without the light of candles. In ſome places, the darkneſs was ſo great, that perſons could not ſee to read common print in the open air, for ſeveral hours together : but I believe this was not generally the caſe. The *extent* of this darkneſs was very remarkable. Our intelligence, in this reſpect, is not ſo particular as I could wiſh : but from the accounts that have been received, it ſeems to have extended all over the *New-England* ſtates. It was obſerved as far eaſt as *Falmouth*.—To the weſtward, we hear of its reaching to the furtheſt parts of *Connecticut*, and *Albany*.—To the ſouthward, it was obſerved all along the ſea-coaſts :—and to the north, as far as our ſettlements extend. It is probable it extended much beyond theſe limits, in ſome directions : but the exact boundaries cannot be aſcertained by any obſervations that I have been able to collect. With regard to its *duration*, it continued in this place at leaſt fourteen hours : but it is probable this was not exactly the ſame in different parts of the country. The *appearance* and *effects* were ſuch as tended to make the proſpect extremely dull and gloomy. Candles were lighted up in the houſes ;—the birds having ſung their evening ſongs, diſappeared, and became ſilent ;—the fowls retired to rooſt ;—the cocks were crowing all around, as at break of day ;—objects could not be diſtinguiſhed but at a very little diſtance ; and every thing bore the appearance and gloom of night.

Such were the general appearances or phenomena of this extraordinary darkneſs. I ſhall now mention ſuch particular obſervations as I have been able to collect, which were either made on this phenomenon, or ſeem to relate to it.

With regard to the ſtate of the atmoſphere preceding this uncommon darkneſs, it was univerſally obſerved for ſeveral days before, that the air appeared to be full of ſmoke and vapour. The ſun and the moon appeared remarkably red in their colour, and diveſted of their brightneſs and lucid appearance: and this obſcuration increaſed as they approached nearer to the horizon. This was obſerved to be the caſe in almoſt all parts of the *New-England* ſtates, for four or five days preceding the 19th of May. The winds had been variable; but chiefly from the S. W. and N. E. The thermometer from 40° to 55°. The barometer rather high for this part of *America*,—from 29 inches 80, to 30 inches 50. The weather had been fair and cool for the ſeaſon.

As to the ſtate of the atmoſphere when the darkneſs came on, it was obſervable, that the weight or gravity of it was gradually decreaſing the bigger part of the day. This may be inferred from the obſervations that were made in this place by the Rev. Profeſſor *Wiggleſworth*, and Mr. *Gannett*. At $12^{h.}$ they found the mercury in the barometer ſtood at 29 inches 70. At $12^{h.}\,30'$, the mercury had fallen the $\frac{1}{100}$ part of an inch. At $1^{h.}$ it was at 29 inches 67. At $3^{h.}$ it was at 29 inches 65. At $8^{h.}\,8'$ it was at 29 inches 64. I made a courſe of barometrical obſervations ſimilar to theſe, at the ſame time, in a different part of the ſtate. I was then at *Bradford*, about thirty miles north of this place, nearly under the ſame meridian, or rather a little to the eaſt. At $6^{h.}$ A. M. I found the mercury in the barometer 29 inches 82. As ſoon as the darkneſs began to appear uncommon, I obſerved the barometer again, and found the mercury at 29 inches 68: this was at $10^{h.}\,20'$. At $10^{h.}\,45'$, the darkneſs aroſe to its greateſt degree in that part of the country; and the mercury was then at 29 inches 67. The darkneſs

neſs continued in the ſame degree for an hour and an half. At $12^{h.}$ 15′, the mercury had fallen to 29 inches 65; and in a few minutes after this, the darkneſs began to abate. The mercury remained in this ſtate until evening, without any ſenſible alteration. At $8^{h.}$ 30′, it ſeemed to have fallen a little; but ſo ſmall was the alteration, that it was attended with ſome uncertainty; nor could I preceive that it ſtood any lower at $11^{h.}$ 30′.

Both theſe barometers appear to be very good inſtruments. That uſed in this place was made by *Champney*: that which I uſed was made by *Nairne*: and they may both be depended on as to the accuracy of their conſtruction. It may, however, be proper to obſerve, that the houſe where I made my obſervations, ſtood at leaſt forty or fifty feet higher than that in which the obſervations were made here.

And from theſe obſervations it is certain, that on the day when the darkneſs took place, the weight or gravity of the atmoſphere was gradually decreaſing through the whole day.*

The colour of objects that day, was alſo worthy of remark. It is mentioned, in the obſervations made by the gentlemen here, that "the complexion of the clouds was compounded of a faint red, yellow, and brown: and that, during the darkneſs, objects, which commonly appear green, were of the deepeſt green, verging to blue; and that thoſe which appear white, were highly tinged with yellow." Much the ſame obſervation was pretty generally made. Almoſt every object appeared to me to be tinged with yellow rather than with any other

* *Farenheit's* thermometer, at *Bradford*, at 6^{h}. A. M. was at 39°. At 12^{h}. it ſtood at 51°. At 9^{h}. P. M. it was at 46°.—At *Cambridge*, at 12^{h}. it was at $51\frac{1}{2}$°. At 3^{h}. P. M. it ſtood at 51°.

other colour. This I found to be the case with every thing I held up to view, whether near, or remote from the eye.

Another thing that deserves our attention is, the nature and appearance of the vapours that were then in the atmosphere. Early in the morning, the weather was cloudy: the sun was but just visible through the clouds, and appeared of a deep red, as it had for several days before. In most places thunder was heard several times in the morning. The clouds soon began to rise from the S. W. with a gentle breeze; and there were several small showers before eight o'clock: and in some places there were showers at other times, throughout the day. The water that fell was found to have an uncommon appearance, being thick, dark and sooty. A gentleman, who was then at *Ipswich*, observes, that "he found the people much surprized with the strange appearance and smell of the rain-water which they had saved in tubs. Upon examining the water, I found (says he) a light scum over it, which rubbing between my thumb and finger, I found to be nothing but the black ashes of burnt leaves: the water gave the same strong sooty smell which we had observed in the air." The same appearance was observed in many other places: and it was very remarkable on *Merrimack-River*. Large quantities of scum, or black ashes, were found floating upon the surface of the water, that day. In the night, the wind veered round to the N. E. and drove it towards the south shore. When the tide fell, it lay along the shore at the width of four or five inches. This I found to be the case for five or six miles;—and probably it was the case for many more. I examined a considerable quantity of this matter; and in taste, colour and smell, it very plainly appeared to be nothing more than what the gentleman observed at *Ipswich*,—

wich,—the black aſhes of burnt leaves, without any ſulphureous, or other mixtures.*

Being apprehenſive whether there was not ſome uncommon matter in the air that day, I put out ſeveral ſheets of clean paper in the air and rain. When they had been out four or five hours, I dried them by the fire. They were much ſullied, and became dark in their colour; and felt as if they had been rubbed with oil or greaſe. But upon burning them, there was not any appearance of ſulphureous or nitrous particles.

The motion and ſituation of the vapours in the atmoſphere, was alſo worthy of notice. In moſt places it was very evident that the vapours were deſcending from the higher parts of the atmoſphere towards the ſurface of the earth. A gentleman, who was then at *Pepperrell*,† mentions a very curious obſervation, as to their *aſcent* and *ſituation*. "About nine o'clock (ſays he) in the morning, after a ſhower, the vapours roſe from the ſprings in the low lands, in great abundance. I took notice of one large column that aſcended with great rapidity, to a conſiderable height above the higheſt hills, and ſoon ſpread into a large cloud; then moved off a little to the weſtward. A ſecond cloud was formed in the ſame manner, from the ſame ſprings, but did not aſcend ſo high as the firſt: and a third was formed from the ſame places, in leſs than a quarter of an hour after the ſecond. About three quarters of an hour after nine o'clock, theſe clouds exhibited a very romantic appearance. The upper cloud appeared of a *rediſh* colour: the ſecond appeared,

* The ſame was obſerved at *Concord* and *Dover* in *New-Hampſhire*: at *Berwick*, and many other places in this ſtate.

† Mr. *Eames*, a Tutor in the Univerſity.

peared, in ſome places, *green ;* in others, *blue ;* and in others, of an *indigo* colour : the third cloud appeared almoſt *white*." One of the gentlemen who obſerved here, mentions a circumſtance of ſomewhat a ſingular nature.—" While the darkneſs continued (ſays he) the clouds were in quick motion, interrupted, ſkirted one over another ; ſo as apparently, and I ſuppoſe, really, to form a conſiderable number of *ſtrata :* the lower *ſtratum* of an uniform height as far as viſible ;—that height conceived to be very ſmall from the ſmall extent of the viſible horizon, and from this circumſtance obſerved in the evening :—Being in the ſtreet, I ſaw a perſon with a lighted torch, which occaſioned a reflection of a faint red light, ſimilar to a faint Aurora Borealis, at a ſmall height above my head. The height at which the reflection appeared to be made, was not more than from twenty to thirty feet."—And it was generally remarked, that the hills might be ſeen at a diſtance in ſome directions, while the intermediate ſpaces were greatly obſcured and darkened.

From theſe obſervations, it ſeems as if the vapours, in ſome places, were aſcending ; in moſt, deſcending ; and in all, very near to the ſurface of the earth. To this we may add, that during the darkneſs, objects appeared to caſt a ſhade in every direction : and that, in many places, there were ſeveral appearances or corruſcations in the atmoſphere, not unlike the *Aurora Borealis :* but I do not find that there were any uncommon appearances of the electric fire any where obſerved that day.*

Having

* In ſeveral accounts it was alſo mentioned, that a number of ſmall birds were found ſuffocated by the vapour. " A number were found dead in ſeveral of the new towns, round the houſes ; and ſome flew into the houſes, as I have been told by eye-witneſſes." Extract of a letter from *Dover*, in *New-Hampſhire*.

Having mentioned the phenomena, with ſuch obſervations upon them, as I have been able to collect, I ſhall now endeavour to account for the cauſe of this unuſual appearance.

From the obſervations that have been mentioned, we may conclude with much certainty, that the atmoſphere, on the 19th of May, was charged with an uncommon quantity of vapour. That this was the caſe, is evident from the large quantity of ſmoke and vapour that appeared in the atmoſphere for ſeveral days before; which was ſo great, as to darken the ſun and moon, and render all objects, at a diſtance, of a dull and very hazy appearance. It was alſo evident, from the deſcent of thoſe large quantities of ſoot, or black aſhes, which, through a long extent of country, were found mingled with the rain that fell, and floating on the ſurface of the waters. And the cauſe from whence the uncommon quantity of theſe vapours was derived, is eaſily aſcertained. It is well known, that in this part of *America*, it is cuſtomary to make large fires in the woods, for the purpoſe of clearing the lands in the new ſettlements. This was the caſe this ſpring, in a much greater degree than is common. In the county of *York*, in the weſtern parts of the ſtate of *New-Hampſhire*, in the weſtern parts of this ſtate, and in *Vermont*, uncommonly large and extenſive fires had been kept up. The people in the new towns had been employed in clearing up their lands this way, for two or three weeks before: and ſome large and extenſive fires had raged in the woods for ſeveral days before they could be extinguiſhed. In addition, therefore, to what ariſes from evaporation, and thoſe exhalations which are conſtant and natural, a much larger quantity of vapour aroſe from thoſe large and numerous fires, which extended all around our frontiers. As the weather had been clear, the

air heavy, and the winds ſmall and variable for ſeveral days; the vapours, inſtead of diſperſing, muſt have been riſing and conſtantly collecting in the air, until the atmoſphere became highly charged with an uncommon quantity of them.

A large quantity of the vapours, thus collected in the atmoſphere, on the 19th of May, were floating near the ſurface of the earth. Whereſoever the ſpecific gravity of any vapour is leſs than the ſpecific gravity of the air, by the laws of fluids, ſuch a vapour will aſcend in the air. Where the ſpecific gravity of a vapour, in the atmoſphere, is greater than that of the air, ſuch a vapour will deſcend: and where the ſpecific gravity of the vapour and air are the ſame, the vapour will then be at reſt,—floating or ſwimming in the atmoſphere, without aſcending or deſcending. From the barometrical obſervations it appears, that the weight or gravity of the atmoſphere was gradually growing leſs, from the morning of the 19th of May, until the evening. And hence the vapours, in moſt places, were deſcending from the higher parts of the atmoſphere, towards the ſurface of the earth. From the obſervation made at *Pepperrell*, it appears, that in ſome places the vapours were aſcending, until they aroſe to an height in which the air was of the ſame ſpecific gravity; where they inſtantly ſpread, and floated in the atmoſphere:—and this height was not much above the adjacent hills. From theſe obſervations, we are lead to conclude, that the place where the vapours were balanced, or became of the ſame ſpecific gravity as the air, muſt have been very near the ſurface of the earth. And hence we may obſerve,

That ſuch a large quantity of vapour, floating in the atmoſphere, near the ſurface of the earth, might be ſufficient to produce

duce all the phenomena that were obſerved May 19, 1780.— Thus the *direction* in which the darkneſs came on, would be determined by the direction of the wind; which accordingly was obſerved to be from the S. W. The *degree* of the darkneſs would depend on the denſity, colour, and ſituation of the clouds and vapour; and the manner in which they would tranſmit, reflect, refract, or abſorb the rays of light. The *extent* of the darkneſs would be as great as the extent of the vapour: and the *duration* of it would continue until the gravity of the air became ſo altered, that the vapours would change their ſituation, by an aſcent or deſcent. All which particulars will, I think, be found to agree very exactly with the obſervations that have been mentioned. Nor does the *effect* of the vapours, in darkening terreſtrial objects, when they lay near the ſurface of the earth, appear to have been greater than it was in darkening the ſun and moon, when their ſituation was higher in the atmoſphere.

Upon the whole, it is evident, that the atmoſphere was charged, in a high degree, with vapours; and that theſe vapours were of different denſities, and occupied different heights. By this means the rays of light falling upon them, muſt have ſuffered a variety of refractions and reflections; and thereby become weakened, abſorbed, or ſo far reflected, as not to fall upon objects on the earth in the uſual manner. And as the different vapours were adapted by their nature, ſituation, or denſity, to abſorb, or tranſmit, the different kind of rays, ſo the colours of objects would appear to be affected by the mixture and prevalency of thoſe rays that were tranſmitted through ſo uncommon a medium.

In what has been ſaid, I have endeavoured to explain what I take to be the cauſe of the late unuſual darkneſs. I would not, however, be underſtood to aſſert, that there could not be any other cauſes or circumſtances which might join to produce this unuſual appearance. Poſſibly there might be cauſes and circumſtances of this nature, of which we have no ſuſpicion. But as the uncommon quantity and ſituation of the vapours in the atmoſphere might be ſufficient to account for the phenomena, it appears to me to be unneceſſary to look out for other cauſes, or to go into a particular examination of the various conjectures that have been advanced upon this ſubject.

It may not be amiſs to obſerve, that ſuch appearances, and from the ſame cauſe, have been obſerved before, in this part of *America*. In the Philoſophical Tranſactions, N°· 423, there is an account of a remarkable darkneſs, which took place October 21, 1716, O. S. It is ſaid, " The day was ſo dark, that people were forced to light candles to eat their dinners by. Which could not be from any eclipſe, the ſolar eclipſe being the 4th of that month." This obſervation was made by Mr. *Robie*, a man of great ingenuity, and formerly a Tutor in the Unverſity : but there is nothing ſaid as to the cauſe, or any other particulars. Several perſons have informed me, that they remember an uncommon darkneſs in the year 1732, Auguſt 9, O. S. and which was afterwards found to be occaſioned by an uncommon fire in *Canada*. It is to be wiſhed, that we could find ſomething more particular upon this ſubject.

There was alſo a remarkable darkneſs at *Detroit*, October 19, 1762, much like that of May 19 ; of which we have this account, by the Rev. *James Stirling*, Phil. Tranſ. for 1763, vol. liii. p. 63. " Tueſday laſt, being the 19th inſt. (i. e. of

" October)

" October) we had almoſt total darkneſs for the moſt of the " day. I got up at day break. About ten minutes after, I ob-" ſerved it got no lighter than before. The ſame darkneſs con-" tinued until nine o'clock, when it cleared up a little. We " then, for the ſpace of about a quarter of an hour, ſaw the " body of the ſun, which appeared as red as blood, and more " than three times as large as uſual. The air, all this time, " which was very denſe, was of a dirty yellowiſh colour. I " was obliged to light candles to ſee to dine, at one o'clock, " notwithſtanding the table was placed cloſe by two large win-" dows. About three, the darkneſs became more horrible; " which augmented until half paſt three, when the wind breez-" ed up from the S. W. and brought on ſome drops of rain, " or rather ſulphur, and dirt; for it appeared more like the " latter than the former, both in ſmell and quality. I took a " leaf of clean paper, and held it out in the rain, which ren-" dered it black whenever the drops fell upon it; but, when " held near the fire, turned to a yellow colour; and when " burned, it fizzed on the paper like wet powder. During this " ſhower, the air was almoſt ſuffocating with a ſtrong ſulphu-" reous ſmell.—It cleared up a little after the rain.

" There were various conjectures about the cauſe of this na-" tural incident. The *Indians*, and vulgar among the *French*, " ſaid, that the *Engliſh*, which lately arrived from *Niagara* in " the veſſel, had brought the plague with them. Others ima-" gined, it might have been occaſioned by the burning of the " woods: but I think it moſt probable, that it might have " been occaſioned by the eruption of ſome volcano, or ſubter-" raneous fire, whereby the ſulphureous matter may have been " emitted in the air, and contained therein, until, meeting with

" ſom:

" some watery clouds, it has fallen down together with the " rain."

We have another account of this phenomena, in a letter from an officer, who was then at *Detroit*, to a friend at *Wilmington*, in *Pennsylvania*. " The 19th of this month, (October, 1762) " was the most extraordinary dark day, perhaps, ever seen in " the world. At nine in the morning, it was scarce lighter " than at break of day, and so continued till about twelve " o'clock,—the air being very full of smoke, accompanied with " a strong smell, as of wood, straw, and other combustibles, " when burning. At half an hour after one, it was so dark " that we were obliged to light candles to dine by. At this " time it rained a little; with which fell a quantity of black " particles, like ashes, as turned every thing it fell upon black. " Even the river (which is twice as wide as *Christiana* in *Penn-* " *sylvania)* was covered with black froth; which, when scum- " ed off the surface, resembled the lather of soap, with this " difference, that it was (and as black as ink) more greasy. At " seven in the evening, the air was more clear, and the disagree- " able smell was now almost gone. We have since been in- " formed, by people who were twenty miles from hence that " day, that the darkness, rain, and smell, was the same with " them."

There does not appear to have been any thing to support the conjecture of a *volcano*, *subterraneous fires*, and *sulphureous matter*. In all other particulars, the phenomena agree to those that were observed among us, and seem to be derived from the same cause.

Felix, qui potuit rerum cognoscere causas,
Atque metus omnes et inexorabile fatum
Subjecit pedibus.——————

V. *An Account of the Effects of Lightning on two Houses in the City of* Philadelphia. *In a Letter from the Hon.* ARTHUR LEE, *Esq; F. A. A. to the Hon.* JAMES BOWDOIN, *L. L. D. Pres. A. A.*

Philadelphia, July 29, 1781.

SIR,

TWO houses, in this city, have been lately struck with lightning, attended with phenomena that are curious, and may be useful; I therefore flatter myself, that an account of them will be agreeable to your Society.

On the 26th June, 1781, about ten o'clock at night, a large house in Market-street, called Mrs. *House's*, occupied by several Members of Congress, was struck by lightning, which entered through the ceiling of the garret, leaving what appear exactly like two bullet-holes. It then glanced along the door, tracing its passage by a blackish line, in an oblique direction, to an iron hinge; and passing from the uppermost hinge to the lowest, pierced thro' the ceiling into the room below; where, meeting immediately with the bell-wire, it was conducted by it, through all the chambers down two stories, till it ended at the bell, which hung over a back door near the kitchen; and its conductor ending there, it split the door to pieces. From this bell there was a wire which should have gone to the street door, but was broke: yet where the bell-handle (which was iron) ended upon the frame of that door, the nearest pannel was split to pieces. It is therefore supposed, that this was a separate portion of the electrical fluid, which was attracted by the iron rod which formed the bell-handle out-side of the door.

The

The houſe was ſhingled, and one ſhingle appeared looſened. A man was in bed in the garret directly under where the fluid entered, and muſt have been ſmitten by it, had not the iron hinge drawn it from that direction to itſelf. The hinge was two feet from one hole, and two feet and an half from the other in an oblique direction. The angle, at the corner of the hinge neareſt the holes, was left very bright; and, probably, that angle operated as a point to attract and receive the electrical matter. The wire, in many places, was melted; and, dropping, burnt the floor. One of the gentlemen, who was in bed in one of the rooms, leaping out upon the floor, burnt the ſoles of his feet, where they touched the wire. To others, the wire ſeemed to be in flames, and a ſulphureous ſmell remained in the chambers. The houſe is higher than any that was near it, ſituated on the ſouth ſide of the ſtreet;—has no point, or conductor, fixt to it;—was ſtruck at the weſtern and eaſtern ends; and the back door, which communicated with the bell-wire, is on the ſouth ſide. The other that was ſtruck, was at the eaſtern end.

On the 8th of July, 1781, the wind being at the northward of weſt, but variable, the houſe of Dr. *Shippen*, jun. [Plate III. Fig. 1.] was alſo ſtruck, in a manner that will be beſt underſtood by the encloſed ſketch, or ground-ſection, [Fig. 2.] of the houſe; though, to comprehend it, we muſt ſuppoſe, that the courſe of the wire, repreſented by the dotted lines, is along the ceiling, inſtead of the floor, as is here repreſented. The traces of the lightning, that appear in the houſe, (for there are none outſide) are theſe.—At the place where the broken wire ends in the paſſage, and is coiled up at *k*, the plaiſter is beat off, about the ſize of a large hand expanded, to the brick wall, which is uninjured. Between the bells, *a* and *b*, the ceiling is raiſed and cracked, in a ſtraight di-

rection,

rection, from one to the other, but not fallen off. At the front door, in the corner, about two feet from the floor, the plaiſter is broke off, as at *n*, in the other end of the paſſage: but there is an apparent trace of the lightning on the bricks, in a blueiſh mark. There is no communication between this and the wire, which runs along the ceiling over it ſixteen or ſeventeen feet diſtant; nor any iron near, except it be the back of the fire-place on the other ſide of the wall, oppoſite to where the plaiſter is beaten off. In the dining-room, the wire is melted from *o* to *p*, and again from *q* to *r*; all the remainder being entire, and the reſt of the wire, in the other parts of the houſe, and the outſide, uninjured. The pieces of wire that fell on the floor, burnt deep holes in it. The conductor being examined, was found to be in good order; but the point, which was copper, was melted ſo as to form a ſort of button; which had not that degree of brightneſs, which thoſe, ſkilled in the fuſion of copper, ſay this metal preſerves for ſome time after its having been melted. This effect upon the point appears, therefore, to be of an older date. The conductor is about half an inch diameter,—enters about two feet into the ground, and is fixt to the wall by ſix iron ſtaples; none of which are nearly oppoſite to the wire in the dining-room. Mrs. *Shippen* felt an electrical ſhock as ſhe ſtood in the paſſage up ſtairs, with her hand on an iron latch. Theſe are the facts;—and the electricians here differ in their opinions, about the manner of the electrical fluid's meeting with the bell-wire. Some think it deſcended through the conductor; but being in a greater quantity than the earth would immediately receive, part quitted the conductor, and paſſed through the wall to the wire neareſt the conductor. The wire being melted in that part, ſeems to lead to this opinion:

but it is alſo melted in a remoter part; which ſeems to ſhew, that it was owing to partial defects in the wire: and if the fluid had quitted the conductor, it would naturally have paſſed off by the ſtaples that enter the wall, and ſhewn its effects in various parts, as they directed. The other opinion is, that it was conducted down the wet roof of the kitchen, which is of ſhingles, unto the corner, where, at *d*, it met with the bell-wire on the outſide of the wall; when part went into the dining-room, and another part into the kitchen; and paſſing from the firſt bell to the ſecond, (which is about a foot from the firſt, while the third is between two and three feet off) and by its wire was conducted into the paſſage to the coil, at *k*, where it took to the wall, and paſſed away. The ſtroke at the front door, muſt have been from a ſeparate ſource: for it does not, on a minute examination, appear probable, that it penetrated through the wall of the dining-room at the corner, *o*, (where the crank of the bell-wire is faſtened to the wall by a ſmall iron nail, entering about two inches) and ſo from that, paſſed to the wire in the paſſage, which continues from thence to the front door. Not the leaſt ſign of injury appears upon the roof of the laundry; nor externally, upon any part of the houſe.

From theſe obſervations we may conclude, that the manner in which the bell-wires are diſtributed in a houſe, is of great moment; and that they ought always to be diſpoſed with a view to the poſſibility of their becoming conductors. From the plaiſter being deſtroyed, and the bricks uninjured, it would ſeem that brick is a conductor, and therefore carried off the fluid without any further effect. That the points of conductors ſhould be examined from time to time; becauſe, in the ſtate in which that of Dr. *Shippen's* houſe was found, and had probably

bably been for ſome time, it would by no means anſwer the end of putting it up. That a conductor on each corner, or on each chimney of a houſe, eſpecially if of any ſize, is neceſſary, to guard it compleatly.

A. LEE.

P. S. Suppoſing that the fluid came to the uppermoſt crank of the wire, at *d*, firſt, it would ſeem that it did not part with that wire, in any portion, to go to the other, which ran cloſe to it, and entered through the ſame holes; nor even to that which goes into the parlour, and is attached to it, but kept to the ſame wire till it ended; which is conformable to what we ſee in experiment.

A ſection of Dr. *Shippen's* houſe, which muſt be ſuppoſed to be that of the upper parts at the ceiling, in order to underſtand the courſe of the bell-wires, and the paſſage of the electrical fluid.

a, The bell in the kitchen, which anſwers to the parlour and dining-room, by the wire which pierces the kitchen wall at *d*, and runs outſide of the paſſage wall to that of the dining-room, which it pierces at *e*, and is continued to the chimney, ending at *f*.—The portions of it, between *o p*, and *q r*, having been melted by the electrical matter.

b, The bell which anſwers to the front door: but the wire was broken at *l*, and hung down upon the wall, ending in a coil at *k*. The bell *b*, is alineated with the bell *a*, and much nearer to it than the third.

c, The bell which anſwers to the bed-chambers up ſtairs, by the faint dotted line, which pierces the wall with the firſt wire;

runs outside with it, and is fixt in the wall, in the corner, by a crank, which is about three inches below that of the dining-room, or first wire; and when it has pierced the wall into the dining-room, at the corner, *e*, makes a short turn, and passes through the ceiling up to the chambers. At *g*, a wire goes off to the parlour.

n, The place where the plaister was beat off in the passage at the front door; as it was at the other end of the passage, directly under the coil, at *k*.

s, Suppose to be the roof of the kitchen, ending directly over, and about twelve feet above the crank of the wire, *d*.

VI. *An Account of the Effects of Lightning on a large Rock in* Glouceſter. *In a Letter from the Rev.* Eli Forbes, *to the Rev.* Manasseh Cutler, *F. A. A.*

Glouceſter, *July* 3, 1783.

Reverend Sir,

ON the 18th of March, 1782, we had a moſt ſevere clap of thunder, and its effects were moſt ſurpriſing. A large rock, of the contents of near ten feet ſquare above ground, received the full weight of its ſhock. It ſtruck the rock near the top, and made an impreſſion like that of a cannon-ball. It broke off near twenty pounds of the ſolid ſtone, and cracked the remaining body in ſeveral directions, though not very deep. Then it ran down on the weſtern ſide of the rock in three directions, or main branches,—each branch marking its path with a chalky colour, tinged with blue. The lightning ſo penetrated the ſolid ſtone, as to alter the texture of its parts, and change its colour an inch deep; which ſtill remains on a large piece of the rock now by me. When theſe three branches reached the ground, they took different routs.——One, that ſeemed to contain the greateſt quantity of the fluid, took its courſe northward. ding the ground, and throwing up cart-loads of earth wh et with large rocks. Some large rocks, whoſe ſurfaces were nearly on a plain with the earth, it paſſed over, with only marking its path, about an inch and an half wide, with the ſame colour as on the rock it ſtruck firſt: then it entered the ground, and tore up the turf about an inch deep. At a rock in its way, which roſe ſome inches above-ground, it divided itſelf into two equal branches, turning up the turf from the

the basis of the rock, till they met on the opposite side, and passed much the same course, till it came to another rock, not quite so high, nor of so wide a base. At this rock it entered the ground, and raised it from its bed about three inches, tho' it was of several tons weight; which was the last effects I could discover of it.

The second main branch, which seemed to contain the next greatest quantity, took its rout westward by a stone wall; on the north side of which was a bank of snow, about six inches deep, and which was now in a watery state. It followed this wall under the snow, rending and removing some of the foundation-stones, and undermining others. Though it passed chiefly on the north side of the wall, under the snow, yet it was not confined to that side; for it crossed under it several times, before it got to the distance of fifty yards. Then it divided itself into two branches; and one turned off southward, across a piece of grass-land, a little descending towards the south, about two rods; which brought it upon a plain, or level, with the ridge of a barn, which stood on a beach near the sea-side, about fifty rods distant from the above-said grass-plot. It entered at the west end, just below the peak,—passed on the under side of the ridge-pole to a king-post, where it again divided into two branches; one ran down the post like an engraver's tool, within four feet of the ground, where about one third part of the post was hewed off; and on the opposite side was a spike, which was just entered into the wood, and stood horizontal:—it passed round the post to the head of the spike;—passed over the head,—drilled a small hole,—returned along the spike to the post, and then, splintering it, continued its course to the ground, and no further traces appeared. The other branch continued its course

on

on the ridge-pole to the end ;—ran down a principal to a corner post, which it pushed down, rending the board which covered it. In its way to the ground it left the post, and passed over two iron bolts that hung a gate to the post, leaving a frosted tract on them ;—returned to the post again, and continued to the bottom, which rested on a flat stone ; and then passed across the beach, about six or eight rods, throwing up the ground and pebble-stones, till it came to the water's edge, and no further effects could be seen. The other branch, at the wall, continued its course by it, producing similar effects as before it divided, until it came near a pond of water, when it entered the ground, and broke out near the water's edge, making a small hole, and could be traced no further.

The third main branch, at the rock first struck, bent its course eastward. In some places it plowed deep furrows in the earth,—throwing up large quantities of earth and stones, and threw some stones, of twenty pounds weight, to the distance of four rods. In other places, it only marked its path as a lambent flame, without removing the lightest bodies that lay in its way, continuing its course to a small collection of water, and there ceased.

A number of persons, within the circle of two hundred yards, very sensibly felt the shock. Those that were abroad were thrown to the ground, and remained senseless some minutes : those that were in the adjacent houses, felt an effect, or shock, like that of electricity ; by which some parts of the body suffered more than others. A young woman, who was leaning with her elbow against a jamb of a chimney, felt it struck numb, and remained so for some hours ; and, when it began to recover, it was in very great pain. Another woman was setting with her

her feet upon a hearth, who felt a violent ſhock acroſs her legs; and her feet and about half way of her legs remained inſenſible for ſome time.

Thus, Sir, I have given you the particulars of the ſurpriſing operations of the lightning; and you may depend on all that I have related to be fact, as I critically examined the whole the next day, and made minutes of the ſame, while on the ſpot: And you may communicate as much of it as you pleaſe to your learned Society.

I am, Sir, &c.

ELI FORBES.

Rev. Mr. Cutler.

N. B. I have encloſed an imperfect ſketch, [Plate III. Fig. 3.] which may aſſiſt you in forming your ideas of the various courſes of the lightning.

VII. *An Account of a very curious Appearance of the electrical Fluid, produced by raising an electrical Kite in the Time of a Thunder-shower. In a Letter from* LOAMMI BALDWIN, *Esq; F. A. A. to the Rev.* JOSEPH WILLARD, *President of the University at* Cambridge, *and V. Pres. A. A.*

Woburn, *May* 26, 1783.

REVEREND SIR,

IN July, 1771, I constructed an electrical kite; the stem of which was about four and an half feet long, and the breadth, at the extremities of the bow, about two feet: the under side was covered with silk. About eight or ten wires, of the size and length of worsted knitting-needles, ground at one of their ends to a sharp point, were, at their opposite ends, inserted into the stem, at equal distances, from one extremity to the other. A very small wire was placed along the stem, with a turn round each point: and each end of the wire, passing through the stem, was continued, entwined round the belly-band, until they met, and communicated with the main flying line, by which the kite was raised. This line was a small, hard cord, and was soaked in water, previous to raising the kite. I also prepared a silk line, in order to insulate the kite after I had raised it to the height intended.

My design was to make some experiments in the time of a thunder-shower, whenever a favourable opportunity should offer. A few days after, there appeared a very heavy thunder-shower rising from the N. W. attended with a violent wind, which was then only evident by the motions and convulsions of the clouds. Circumstances, by this time, became favourable for

 my

my designs, although it was yet calm where I was. I made ready my apparatus; and the wind freshened up, and presently blew a considerably hard gale. The highest verge of the rising cloud was not yet elevated more than to the fifty-fifth or sixtieth degree from the horizon, but attended with the most piercing shafts of lightning, and tremendous thunder that I had ever beheld or heard, at the same distance,—and the zenith still serene. I adjusted the lines of the kite as near as I could to the strength and power of the wind, and soon raised it to the height of some lofty trees, which stood near my house, or perhaps something higher, but I am sure not much. By this time I discovered a rare medium of fire between my eyes and the kite.—I cast my eyes towards the ground;—the same appearance was there.—I turned myself around;—the same appearance still between me and every object I cast my eyes upon.—I felt myself somewhat alarmed at the appearance. I stood, however, and reasoned with myself upon the cause, for some time, but gained very little satisfaction,—the same fiery atmosphere surrounded me, only more bright and apparent. I was about to discontinue my experiments for that time; but reason accused imagination with error; and supposing it might possibly be only fancy, not knowing the cause of such an appearance, and feeling no very bad effects from it, I continued to raise the kite. The cloud had not yet quite obscured the heavens over me, but appeared still to be very highly, though unequally, charged with the electrical fluid; which, by gaining an equilibrium, caused an incessant rattling, as if the heavens were rending asunder. All this time, the fiery atmosphere was increasing and extending itself, with some faint gentle flashings; but with no other effects upon me than a general weakness in my joints and limbs, and a kind of

of listless feeling: all which might possibly be only the effect of surprise:—however, it was sufficient to discourage me from any further attempts at that time. I drew in the kite, and retired into a shop, which stood near my house, and continued there until the shower (which was [illegible] very severe) was over, and then went into my house, where I found my parents and family vastly more surprised than I had been myself; who, after expressing their astonishment, informed me, that I appeared to them (during the time I was raising the kite) to be in the midst of a large bright flame of fire, attended with flashings; and expected, every moment, to see me fall a sacrifice to the flame. The same was observed by some of my neighbours, who lived near the place where I stood.

I shall make no remarks, at this time, upon the cause; but leave it for the present to the consideration of the learned.

I am, Sir, &c.

LOAMMI BALDWIN.

The Rev. President Willard, *Corresponding-Secretary of the* American *Academy of Arts and Sciences.*

VIII. *Observations and Conjectures on the Earthquakes of* New-England. *By Professor* WILLIAMS, *F. A. A.*

IN looking over some of the histories of *New-England*, I observed, that the religious turn of mind which distinguished the first planters of *New-England*, had lead them to take notice of all the Earthquakes which happened in the country, after their arrival. Several of them seemed to be pretty well described; and in some of their phenomena, there seemed to be an agreement. As several of these accounts were contained in writings but little known, I thought it might be of some service to philosophy, if a particular account of them could be collected. This is what I have attempted in the following treatise. In the *first part* of it, I have set down the most particular accounts I could find of their phenomena. The *second* contains observations and remarks upon their agreement and operations. In the *third*, conjectures are proposed as to their causes: and in the *fourth*, some general reflections are added as to their nature, use, and effects.

The most likely way to come to the knowledge of their causes, is to observe all the phenomena that attend them. That the reader might have a true account of these phenomena, it was my endeavour, in the accounts and observations, to note all the particulars that seemed to relate to them, however minute or trivial some of them might appear. With this view, I consulted all the accounts I could find. From several of them, (the Honourable Professor *Winthrop's* Lectures on Earthquakes, in particular) I have received much help. Others referred to authors of which I could not have the advantage of a perusal. That gentlemen of science might have it in their power to examine

amine with what fidelity and care the accounts are drawn up, or how far they might be depended upon, I have constantly referred to the authors from which they are taken. Some of the accounts, I am sensible, are greatly imperfect: as all our conjectures, theories, and reasonings, must depend on the accounts, it is much to be wished, that something more accurate and perfect, as to several of them, might be transmitted down to posterity.

What is proposed as to their *causes*, will be judged of, by the degree of probability and evidence with which it is attended. In all philosophical hypotheses, a writer is in danger of making more of his subject than will bear a strict examination. I have found some difficulty in guarding against this: and whether, at last, I have not carried *conjectures*, in some things, too far, the reader must judge for himself. After all, the revolutions of time will afford the surest proof of the truth or errors contained in the following pages. I would, therefore, make it my request to posterity, to note, with care and accuracy, the phenomena that may attend any future earthquakes in *New-England*; that, if what is here advanced as to their causes, shall be found to be true, it may be confirmed; but, if found to be false, it may meet with the fate of other errors, and be rejected. The cause of truth and science, is of infinitely more importance, than any of our schemes or conjectures: and this is what I wish may prevail, in all countries, and in all ages.

An

An HISTORICAL ACCOUNT of the EARTHQUAKES of NEW-ENGLAND.

THE *English* arrived at *Plimouth*, in *New-England*, November 11, 1628. The *first* earthquake that happened in the country after their arrival, was on July 2, 1638, O. S. The *manner* of its approach, and the *violence* to which it arose, are pretty well described in accounts which are yet existing. It is described as having been preceded with a rumbling noise, or low murmur, like remote thunder. As the noise approached, the earth began to quake, till the shock arose to such a violence, as to throw down the pewter from the shelves, stone walls, and the tops of several chimnies; and, in some places, made it difficult for people to avoid falling. The *course* of this earthquake, in some of the accounts, is described as being from the westward to the eastward. In others, it is represented as coming from the northward, and going off southward. It is not likely any great care, or accuracy, was employed, to determine what particular point of the compass the roar or shake came from; but only to fix it to that, which was judged to be the nearest cardinal point, which some thought was the west, others the north. It is most probable, therefore, that a middle course, from about north-west to south-east, was the true; as this will best agree with, and reconcile all the other accounts that were given of its course. To what *extent* this earthquake reached, on any point of the compass, we have no way to determine.— It is said in general, that it reached far into the land, and was observed by the *Indians* much beyond any of the *English* settlements, which then were but of small extent. And also, that some vessels, which were near the coast, were shaken by it. In

In about half an hour there was another ſhock, but not ſo long or ſtrong as the former.*

Omitting a ſhock on October 29, 1653, as too ſmall to occaſion a general notice, the next memorable earthquake, was in 1658. In all the ancient hiſtories, this is mentioned as a *great* earthquake. But I cannot find any account of the month, day, violence, courſe, effects, extent, or any other particulars of it.

On January 26, 1663, O. S. " at the ſhutting in of the evening,"† another memorable earthquake ſhook *New-England*. From the general expreſſions the writers who ſpeak of it uſe, it ſeems to have been one of the *greateſt* this country ever felt. It is repreſented as being preceded with a great noiſe and roar. Mention is made of the houſes rocking, the pewter falling from the ſhelves, the tops of ſeveral chimnies falling in, the inhabitants running out into the ſtreets, paſſengers being unable to keep on their feet, &c. As to its *courſe*, *duration*, or *extent*, nothing is to be found in any of the *New-England* writers. But they are well deſcribed in the accounts that were given of this earthquake in *Canada*.

At the ſame time, February 5, 1663, N. S. " about half an hour after five in the evening," a moſt terrible earthquake began there. The heavens being very ſerene, there was ſuddenly heard a roar, like that of a great fire. Immediately the buildings were ſhaken with amazing violence. The doors opened and ſhut of themſelves, with a fearful clattering. The bells rang, without being touched. The walls ſplit aſunder. The floors ſeparated, and fell down. The fields put on the appearance of precipices,

* Vide *Johnſon's*, *Hubbard's*, and *Morton's* accounts of this earthquake.

† *Morton*.

precipices; and the mountains ſeemed to be moving out of their places: and amidſt the univerſal craſh which took place, moſt kinds of animals ſent forth fearful cries and howlings.

The *duration* of this earthquake was very uncommon. The firſt ſhock continued half an hour before it was over; but it began to abate in about a quarter of an hour after it firſt began. The ſame day, about eight o'clock in the evening, there was a ſecond ſhock, equally violent as the firſt; and in the ſpace of half and hour, there were two others. The next day, about three hours from the morning, there was a violent ſhock, which laſted a long time: and the next night, ſome counted thirty-two ſhocks; of which, many were violent.—Nor did theſe earthquakes ceaſe until the July following.

New-England and *New-York* were ſhaken with no leſs violence than the *French* country. And, throughout an *extent* of three hundred leagues from eaſt to weſt, and more than one hundred and fifty from north to ſouth, the earth, the rivers, and the banks of the ſea, were ſhaken with the ſame violence. The ſhocks ſometimes came on ſuddenly; at other times by degrees. Some ſeemed to be directed upwards; others were attended with an undulatory motion.—And throughout the vaſt extent of country to which they reached, they ſeemed to reſemble the motions of an intermitting pulſe, with irregular returns; and which commenced through the whole at the ſame hour.

This earthquake was attended with ſome remarkable *effects*. Many fountains and ſmall rivers were dried up. In others, the water became ſulphureous: and in ſome, the channel in which they ran before, was ſo altered that it could not be diſtinguiſhed. Many trees were torn up, and thrown to a conſiderable diſtance.

And

And ſome mountains appeared to be much broken and moved. Half way between *Tadouſſac* and *Quebec*, two mountains were ſhaken down: and the earth thus thrown down, formed a point of land, which extended half a quarter of a league into the river *St. Lawrence*. The iſland *Aux Coudres*, became larger than it was before: and the channel in the river, became much altered.*

From theſe accounts it is evident, that *Canada* was the chief ſeat of theſe concuſſions: and of conſequence, as it proceeded from thoſe parts, its *courſe* muſt have been from ſome point between the weſt and north; probably much the ſame with that of 1638.

After an interval of ſixty-four years, (in which there had been ſeveral ſmall ſhocks, but none ſo violent as to occaſion a very long remembrance†) there came on another very memorable one, October 29, 1727, O. S. About $10^{h.}$ 40', P. M. in a very clear air and ſerene ſky, when every thing ſeemed to be in a moſt perfect calm and tranquility, a heavy rumbling noiſe was heard. At firſt it ſeemed to be at a diſtance, but increaſed as it came near, till it was thought equal to the roar of a blazing chimney, and at laſt to the rattling of carriages, driving fiercely on pavements. In about half a minute from the time the report was firſt heard, the earthquake came on. It

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* Vide *Frezier's* Voyage, p. 210, 211. Journal des *Scavans Mai.* 1678. *Charlevoix's* Hiſtoire de la *Nouvelle France*.

† In Phil. Tranſ. No. 437, mention is made of earthquakes in 1660, 1665, 1668 and 1669. Dr. *Mather* ſpeaks of earthquakes in 1670 and in 1705. There was another in 1720, on January 8. But theſe, with ſome others, having been too ſmall to occaſion a general notice, and being only mentioned without any particular account of them, are paſſed by, as not affording us any light with regard to the nature, cauſe, or effects of theſe phenomena.

was obſerved by thoſe that were abroad, that as the ſhake paſſed under them, the ſurface of the earth ſenſibly roſe up, and then ſunk down again; which muſt have produced an *undulation* of the earth, or a motion like that of a wave, both perpendicular and horizontal; firſt riſing in a perpendicular direction, and as it ſubſided, ſpreading itſelf in a horizontal direction all around. The nature, therefore, or *kind* of the *motion*, was *undulatory*. The *violence* of the ſhock, like that of the other great earthquakes, was ſuch as to cauſe the houſes to ſhake and rock, as if they were falling to pieces. The doors, windows, and movables, made a fearful clattering. The pewter and china were thrown from their ſhelves. Stone walls, and the tops of ſeveral chimnies were ſhaken down. In ſome places, the doors were unlatched and burſt open, and people in great danger of falling. There were various opinions as to the *duration* of this earthquake. The moſt probable is, that the ſhake began about half a minute after the roar was firſt heard, and roſe to its greateſt height in about a minute more; and was about half a minute in going off. Whence, the *duration* may be ſuppoſed to have been about two minutes. It was very generally agreed, that the *courſe* of this earthquake was from north-weſt to ſouth-eaſt. "The noiſe and ſhakes, it is ſaid, ſeemed to come from the "north-weſtward, and to go off ſouth-eaſterly; and ſo the "houſes ſeemed to reel." This account of its courſe, was confirmed by all the others, one or two excepted, which differ ſo much from one another, that nothing can be determined from them. With regard to the *limits* of this earthquake, it extended from the river *Delaware*, in *Pennſylvania*, ſouth-weſt, to *Kennebeck*, north-eaſt. At both theſe places it was ſenſibly felt, though the ſhake was but ſmall. Its extent, therefore,

from

from south-west to north-east, must at least have been seven hundred miles, and probably many more. As to its other limit, from north-west to south-east, we have no way to determine how far it extended. It was felt by vessels at sea, and in the most remote westerly settlements. As it came from the unknown parts, between the west and north, and passed off into the sea, it is probable it might run some thousand miles in such a course.

There were several *effects* attending this earthquake, which seem worthy of remark. Besides what is common, as to the throwing down pewter, fences, &c. it was observed, that several springs of water, and wells, that were never known to be dry or frozen, were sunk far down into the earth. Some were dried up. The quality of the water mended in some, and so altered in others as to freeze in moderate weather. Some spots of firm dry soil, became perfect quagmires; and others, that were full of mire and water before, became more dry. The centre of this earthquake, or place of greatest violence, seems to have been at *Newbury*, a town which lies at the mouth of *Merrimack-River*. "There, (according to Dr. *Colman's* account) "the earth opened, and threw up several loads of a fine "sand and ashes, mixt with some small remains of sulphur; "so that, taking up some of it between the fingers, and drop-"ping it into a chaffing-dish of bright coals, in a dark place, "once in three times the blue flame of the sulphur would "plainly arise, and yield a very small scent. By this it seems "evident, that it was a sulphureous blast which burst open the "ground, and threw up the calcined bituminous earth."* Con-

* Phil. Trans. No. 409. What is here said of its being a sulphureous blast, seems to be confirmed by the account which Mr. *Dudley* sent to the Royal Society, in which

cerning this earth which was thrown up, the Rev. Mr. *Lowel*, minister in *Newbury*, mentions an uncommon circumstance. "One thing (says he) I may add, which is very remarkable, "and which may be depended on: that about the middle of "April, that fine sand, which was thrown up in several places "in this parish, at the first great shock, October 29, had a very "offensive stench; nay, was more nauseous than a putrifying "corps; yet, in a very little while after it had no smell at all. "How long it was before it begun to have this stench I am "not certain. I know it had it not at first: and, I believe, it "was covered with snow till a little while before.—There is no "smell now."* These accounts refer to matters so easy to be known, that there is no room to suspect that the authors (both gentlemen of a philosophic taste, as well as of eminence in their particular professions) could be mistaken. And it seems highly probable, from their observations, that the sand which was thrown out by the earthquake, contained some very noxious, ill-scented vapour, or effluvia; which, so long as there was nothing to confine it, passed away in quantities too small to be perceptible to the senses: but when it was kept together by the snow, gathered in such quantities as strongly to infect the air, when the melting of the snow gave it liberty to evaporate freely.

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which he says, "A clergyman in a town about twenty miles from *Boston* assured "him, that immediately after the earthquake, there was such a stink, or strong "smell of sulphur, that the family could scarce bear to be in the house for a consi- "derable time that night. The like is also confirmed from other places. Persons "of credit do also affirm, that just before, or in the time of the earthquake, they "perceived flashes of light." Phil. Transf. No. 437.

* Letter to Dr. *Colman*. Phil. Transf. No. 409.

Some *phenomena* were observed a few days before this earthquake, which deserve our notice, as having, probably, some *connection* with its approach. The Rev. Mr. *Allin*, then minister of *Brooklyn*, took notice of an uncommon alteration in the water of some wells. " About three days (says he) before " the earthquake, there was perceived, an ill-stinking smell in " the water of several wells. Not thinking of the proper cause, " some searched their wells, but found nothing that might thus " infect them. The scent was so strong and offensive, that for " about eight or ten days they entirely omitted using it. In " the deepest of these wells, which was about thirty-six feet, " the water was turned to a brimstone colour, but had nothing " of the smell ; and was thick like *puddle-water*."§ We have this account confirmed by Mr. *Dudley*.—" A neighbour of his " that had a well thirty-six feet deep, about three days before " the earthquake, was surprised to find his water, that used to " be very sweet and limpid, stink to that degree that they could " make no use of it, nor scarce bear the house when it was " brought in ; and imagining that some carrion was got into " the well, he searched the bottom, but found it clear and good, " though the colour of the water was turned wheyish, or pale. " In about seven days after the earthquake, the water began to " mend ; and in three days more, it returned to its former " sweetness and colour."* And just before the earthquake began, several wells were found to have no water in them, which had great quantities before and after. To whatever cause the alterations in these wells be ascribed, it can hardly be thought but that they had some *connection* with the earthquake, which in

§ Account of the earthquake of 1727, by Mr. *Allin*.

* Phil. Transf. No. 437.

in a few days ran through the whole country. Several ſhocks were felt in the northern parts of *New-England*, for ſome months after that of October 29 : but they were generally ſmall and of a ſhort duration.*

In 1732, there was an earthquake, which, though ſmall, was of a conſiderable extent. It came on September 5, O. S. at about $11^{h.}$ A. M. being attended with a rumbling noiſe ; and was of ſuch *violence* as to occaſion a conſiderable jarring of the houſes. The *duration* of it, was not more than ten or fifteen ſeconds. This earthquake was much more evident at *Montreal* in *Canada*, than it was in any part of *New-England* ; being attended with conſiderable damage there. As this was the chief ſeat of it, it ſeems to have come from thence, in a *northweſterly courſe*, to *New-England*. Its *extent*, from ſouth-weſt to north-eaſt, was equal to that of moſt of the earthquakes that have been in the country ; being felt from *Maryland* to the *northeaſterly* parts of *New-England :* and from north-weſt to ſouth-eaſt, it reached from *Montreal*, and probably from many miles beyond it, to the ſea-coaſt.||

From the year 1732, though there had been ſome ſmall ſhocks, there was none that occaſioned a general notice, till 1744. That year, on June 3, O. S. a fair and hot day, there was an earthquake, ſo conſiderable, as to be generally felt thro' the province. It began a few minutes after $10^{h.}$ A. M. being preceded

* The account of this earthquake is collected from the printed accounts of it in the Philoſophical Tranſactions, and by ſeveral of the *New-England* miniſters.

|| Vide Phil. Tranſ. No. 429, and for 1757, p. 13, and alſo Profeſſor *Kalm's* travels, vol. i. p. 44, 2d edit. *London*. On February 6, 1737, at 4¼ P. M. and December 7, a little before eleven at night, ſmall earthquakes were felt at *Boſton :* but no particulars are mentioned as to their phenomena.

preceded with a very loud report; and is ſaid to have roſe to ſuch a *violence*, as to ſhake down ſome bricks from the tops of ſome chimnies, and alſo ſome pieces of ſtone wall. The *courſe* of this earthquake is ſaid, by ſome that remember it, to have been from the *weſtward* to the *eaſtward*. As to other particulars I can find no account.†

The next earthquake, that ſhook the whole country, was in the year 1755. November 18, N. S. at $4^{h.}$ 11′ 35″,‡ in a calm, ſerene and pleaſant night, came on the moſt violent ſhock of an earthquake that was ever known in *New-England*. The firſt thing obſervable, was that rumbling noiſe, or roar, which as a ſound *ſui generis*, ſeemed a prelude to an earthquake. In about half a minute, the ſurface of the earth ſeemed to be ſuddenly raiſed up; and, in ſubſiding, was thrown into a univerſal trembling, or a very quick, jarring, vibratory motion, which acted in an horizontal direction. This motion continued for about a quarter of a minute, and then abated for three or four ſeconds. Then, all at once, came on a violent, prodigious ſhock, as ſuddenly, to appearance, as a thunder-clap breaking upon

† Phil. Tranſ. for 1757, p. 14, and *American* Mag. for 1744.

‡ The beginning of this earthquake was determined to all the exactneſs that could be deſired, by the following accident.—Profeſſor *Winthrop* at *Cambridge*, ſome time before, having uſed a pretty long glaſs tube, in a particular experiment, ſhut it up in his clock-caſe, for ſecurity. This tube, ſtanding nearly perpendicular, muſt have been overſet by the firſt ſhock, which made it impoſſible for the pendulum to make any oſcillation, after the tube had ſtruck againſt it. The clock ſtopped at the time mentioned above. Being a very good one, and having been adjuſted by a meridian line, the preceding noon, it muſt have pointed out the beginning of the earthquake to a great preciſion. Had the time been as accurately determined at any other diſtant place, the velocity of its motion might have been determined to great exactneſs.

upon a houſe, and attended with a great noiſe. This ſudden and great ſhock began with the ſame *kind* of motion; and was immediately ſucceeded by quick and violent concuſſions, jerks and wrenches, attended "with an undulatory, waving motion of the whole ſurface of the ground, not unlike the ſhaking and quaking of a very large bogg." After this great ſhock had been gradually declining and going off, near half a minute, there was a ſenſible revival of it, though of ſhort continuance; and ſo all by degrees became ſtill and quiet again.

The *violence* of this earthquake was the greateſt of any we have ever had in the country. "In *Boſton*, beſides the throwing down of glaſs, pewter, and other movables in the houſes, about an hundred chimnies were, in a manner, levelled with the roofs of the houſes; and about fifteen hundred ſhattered, and thrown down in part. Some were broken off ſeveral feet below the top; and by the ſuddenneſs and violence of the jerks, canted horizontally an inch or two over, ſo as to ſtand very dangerouſly. Some others, thus broken off, were turned round ſeveral points of the compaſs, as with a circular motion. The roofs of ſome houſes were quite broken in by the fall of chimnies. The ends of about twelve or fifteen brick buildings were thrown down, from the top to the eaves of the houſes. Many clocks were ſtopped. The vane upon the public market-houſe was thrown down;—the wooden ſpindle, which ſupported it, being broken off at a place where it was five inches in diameter, and ten feet in height; and which had ſtood the moſt violent guſts of wind. A new vane, upon one of the churches in the town, was bent at the ſpindle, two or three points of the compaſs: and a diſtiller's ciſtern, made of plank, almoſt new, and very ſtrongly put together, was burſt to pieces, by the agitation of the

the liquour in it; which was thrown out with ſuch force, as to break down one whole ſide of the ſhed that defended the the ciſtern from the weather; as alſo to ſtave off a board or two from a fence, at the diſtance of eight or ten feet from it." Much the ſame things were obſerved in the country. At *Springfield*, a town diſtant about eighty miles in a weſterly line from *Boſton*, a ſpindle on one of their churches, was bent to a right-angle.—And through the whole province, much damage was done by the throwing down of ſtone fences, cellar walls, chimnies, and the like. Theſe things may ſerve to give us pretty juſt ideas of its *violence*: but it is to be obſerved, that the violence of the ſhock was different in different places; and not exactly the ſame in towns contiguous to one another; or indeed in all the parts of the ſame town.

There has been no earthquake in the country, whoſe *duration* was determined with ſo much accuracy as was that of this. Profeſſor *Winthrop* at *Cambridge*, the day before, had adjuſted his clock and watch by a meridian line. His clock was ſtopped at $4^{h.}\ 11'\ 35''$. Being awaked by the earthquake, he aroſe, and looking upon his watch, found it to be fifteen minutes after four. The jarring continued about a minute after this. The next day the watch was found to have kept time very exactly. So that the *duration* of the earthquake, taking in the whole of the time from the firſt agitation of the earth, till it became perfectly quiet, was very nearly four and an half minutes; though the violence of the ſhock did not laſt half ſo long. This obſervation of its duration at *Cambridge*, agreed pretty well with ſome of the ſame kind made at *Boſton*, by gentlemen who were up, and looked upon their watches when it began and ended.

In other places, its duration might be different, according to the different violence of the ſhock.

By the accounts of thoſe who were in the commons and open places, when the earthquake began, the *courſe* of it was nearly from north-weſt to ſouth-eaſt. It was almoſt univerſally agreed, that the noiſe and ſhakes ſeemed to paſs in that direction: and thoſe things which were in ſuch a ſituation as that they might have been thrown indifferently to any point of the compaſs, pretty generally lay in that direction.

The *extent* of this earthquake, was traced to a great diſtance. On the ſouth-weſt, it reached as far as *Cheſapeake-Bay* in *Maryland:* being felt on the eaſtern, but not on the weſtern ſide. To the north-eaſt, it was felt as far as *Halifax*. It is much more difficult to determine its weſtern or eaſtern limit.—It extended to all our back ſettlements;—was felt at *Lake George*, and probably many miles beyond: but at *Oſwego*, ſituate on the ſouth-eaſtern ſhore of *Lake Ontario*, and diſtant from *Boſton* about two hundred and fifty miles weſt-by-north, it was not felt at all. On the *Atlantic*, the ſhock was ſo great ſeventy leagues eaſt of *Cape Ann*, that the people on board a veſſel, in that longitude, thought they had run aground, or ſtruck upon a rock, till on ſounding they found they had more than fifty fathom water. By accounts, which were ſoon after received from the *Weſt-Indies*, it ſeems probable that the earthquake reached as far as thoſe iſlands; or, rather, paſſed by to the eaſtward of them. The account was, "That on the 18th of November, "about two o'clock in the afternoon, the ſea withdrew from "the harbour of *St. Martin's*, leaving the veſſels dry, and fiſh "on the banks, where there uſed to be three or four fathom "water: and it continued out a conſiderable time; ſo that the

"people

" people retired to the high lands, fearing the consequence of
" its return: and when it came in, it arose six feet higher than
" usual, so as to overflow the low lands. There was no shock
" felt at the above time."

As this extraordinary motion of the sea happened about nine hours after the great shock was felt in *New-England*, it seems very likely to have been occasioned by the same convulsion of the earth. As this earthquake went off south-eastward into the *Atlantic*, it would pass considerably to the eastward of *St. Martin's*, which has about 18° of north latitude, with 62½° of west longitude. And this was the case at the island. There was no shock felt; but the motion of the sea was probably owing to a great agitation, raised at a considerable distance, in some part of the ocean, by the passage, or by an eruption of the earthquake, and from thence propagated to that island.— And what seems to be a confirmation of this, the length of time was no greater than what seems necessary for such a purpose. We cannot, indeed, state, with great accuracy, the *velocity* with which the earthquake moved: but yet it is very evident from its duration, and being preceded with a roar, that its motion was not very swift: and that of the waves, raised thereby, and propagated to the land, must have been much slower: both of which might easily take up nine hours in being propagated, and that in a circular direction, to such a distance as that of *Boston* and *St Martin's*. The *extent*, therefore, of this earthquake, from south-west to north-east, must have been about eight hundred miles: but from north-west to south-east, it reached at least nineteen hundred; and, perhaps, many more.

As the *effects* of this earthquake, great alterations were observed in the springs, wells and ponds of water. In some, the quality of the water was altered; in others, the quantity. New springs were opened; old ones dried up: the channel in many, was much changed; and the water in some was observed to boil up in an unusual manner, for several days both before and after the earthquake. At *Pembroke*, *Scituate* and *Lancaster*, there were chasms made in the earth. At *Pembroke*, there were four or five of them; out of some of which, water issued, and many cart-loads of a fine, whitish and compressible sort of sand, was spewed.* Nor were its effects confined to the land;—several of the sea-faring men agreed in their accounts, that almost immediately after the earthquake, large numbers of fish, of different sorts, both great and small, came up to the surface of the water,—some dead, and others dying. One of the fishing vessels, at that time out upon the *Banks*, took up and brought in several quintals of these fish, which were found in large numbers, dead and dying, upon the surface of the sea.†

There

* Speaking of this sand, "By what I have heard," says Dr. *Mayhew*, "it was "of a sulphureous nature." It is to be regretted, that no experiments were made with it, to determine, with certainty, whether this was the case or not.

† In phenomena, of whose causes we have so little knowledge, it is best to note every circumstance however minute, and whether it seems to have much connection with the supposed causes or not; as we do not know but that they may be of use, when future observations come to be compared with them. For this reason, it may not be amiss to subjoin to the above account, 1. That at the time of the earthquake, there was no alteration in the atmosphere, as to its weight or temperature: the *barometer* and *thermometer* not undergoing any alteration. 2. A very great white frost was observed in the morning, much larger than had been for several years. When it was melted, Professor *Winthrop* measured it, and found that it covered the ground

There were several small shocks soon after this of November 18.—One in about an hour and a quarter after the first, viz. at $5^{h.}$ $29'$. A second, on November 22, at twenty-seven minutes after eight at night. A third, on December 19, at $10^{h.}$ P. M. Their *violence* and *duration* was small ; their *course*, much like that of the great shock ; and their *extent*, such as to be pretty generally felt through the country. Many others, but very small, were felt in different parts of the *Massachusetts* and *New-Hampshire*, for several months after.

In 1757, there was another earthquake ; which, tho' small, was generally felt. I cannot find any printed account of this shock, and, therefore, can only mention some general observations, which I then made of it. It came on July 8, N. S. at about $2^{h.}$ $20'$, P. M. I was then in an open field, surrounded with pretty high hills, from south-west to north-east, in company with another person. The first thing we perceived, was a small noise, like that of a rising wind, which seemed to be at a great distance, but swiftly advancing. It was half a minute before there was any shock. This I inferred, not barely from any conjecture I was then able to make, which in a state of surprise must be greatly uncertain, but from this circumstance : after hearing the noise, we had enquired of each other what it could be ; and as there was no shake, concluded it was not an earthquake, when immediately the shock came on. The conversation I well remember ; and am certain it must have taken up half a minute, if not more. The *shock* itself was not of very great

ground $\frac{17}{1000}$ parts of an inch ; which was almost double of any there had been for seven years before, and about five or six times as great as what is common in this country. The account of this earthquake is collected from Professor *Winthrop's* Lecture, and account of it in Phil. Transf. for 1757, art. 1. and from Drs. *Chauncey's* and *Mayhew's* accounts of it.

great force; but seemed as though some small body was swiftly rolling along under the earth, which gently raised up that part of the surface that was over it, and then left it as gently to subside. The *course* of this earthquake appeared, to me, to be from the south-west to the north-east.—The noise and shake seemed very plainly to come on, and go off in that direction. I might, however, be deceived by the reflection of the sound from the adjacent hills, or from some other cause; for almost every one judged very differently of its *course*, that it was from north-west to south-east. This was the judgment of several men, who were at work together, in a large open field, where there was nothing to reflect the sound, or mislead the judgment. It is not impossible that both might have been right in their opinion; and this, upon the whole, I am apt to think was the case: that although its general *course* was from north-west to south-east, yet, in particular places, it left its general course, and run out to any point of the compass, as the subterraneous veins, or channels, might lead it. From the effects of other earthquakes, particularly that of turning and twisting chimnies, &c. it seems as though this had been the case with most of the large earthquakes we have had.

On the 12th of March, 1761, there was also a small earthquake. It began about 2h. 30′ in the morning. It was said to have been divided into two shocks, with a small pause between, the last of which was the greatest. The weather was moderate, like that of the preceding day, and a perfect calm rested on the land and water; the horizon, all around, being covered with a whitish fog. The *duration* was supposed to be about half a minute. Happening in the night, and being too small to awake people in general, nothing can be collected with any certainty

as

as to its *course*. Its *extent*, however, was considerable; being felt not only in the *Massachusetts*, but in most of the adjoining states.

The same year, on November 1, about 8h. P. M. there was another earthquake. As usual, this was preceded with a heavy rumbling noise, which increased to a pretty loud report as it came near. There was a considerable interval of time between the roar and the shake. I endeavoured to make some computation of it by this method: just as the shock began to abate, I looked on my watch to note the time. The report I could hear for about half a minute after this. It is probable it was about as long in coming on, which would give half a minute between the noise and shake. The *shock* itself was of the *undulatory* kind; not *violent*, but sufficient to make the doors and windows jarr and clatter. Its *course* was very plainly from northwest to south-east, and it was pretty generally felt through the state, and in *New-Hampshire*.

In the years 1766, 1769, and 1771, there were small earthquakes. Their *courses* were all, I think, from about northwest to south-east. Their *durations* not more than twelve or fifteen seconds; and their *extent* but small. Not being attended with any thing remarkable, it is not necessary to write particular accounts of them.

November 29, 1783, about 10h. 54′, P. M. there was another small earthquake in *New-England*. Its *extent* was very considerable; being felt in *Pennsylvania*, *New-Jersey*, *New-York*, *Connecticut*, *Rhode-Island*, *Massachusetts* and *New-Hampshire*. At *Boston*, there was but one shock; and that was not violent enough to be generally perceived. At *Hartford* and *New-Haven*, in *Connecticut*, but one shock was perceived; but it

it seems to have been more considerable than at *Boston*. At *New-York*, three shocks were felt, about the hours of nine, eleven, and two the next morning. At *Philadelphia*, they had a shock about eleven o'clock, and another the next morning, about two. At the first of these, " most of the houses were " very sensibly shaken," but the other was not generally felt. Being but small in most places, and happening in the night, the *course* of this earthquake was not much attended to. The only remark I can find upon this, is in an account from *New-Haven*; in which it is said, " Its *course* was nearly from north " to south, and it continued about one minute."

OBSERVATIONS and REMARKS on the EARTHQUAKES of *NEW-ENGLAND.*

TO have a general view of the agreement and disagreement of the phenomena that have attended the earthquakes of *New-England*, it may be of use to make some general observations on the preceding HISTORICAL ACCOUNT.

It seems worthy of remark, that all the earthquakes of this country, have been of the same *kind*. Writers on this subject, have sometimes distinguished earthquakes into two different kinds, according to the different *motions* of which they have consisted.—In some, an *horizontal*, in others, a *perpendicular* motion has been chiefly observed. In the one, the earth seemed to move, as it were, from side to side: in the other, its motion seemed to be up and down. Both these motions have been united in the earthquakes of *New-England*. All, of which we have had any particular account, have come on with an

an *undulatory* motion, like that of a wave ; which firſt riſes till it comes to its greateſt height, and then ſubſides ; and in ſubſiding, ſpreads itſelf, with an horizontal motion, all around. This has appeared, with the moſt ſenſible evidence, to be the caſe, in all the earthquakes I have ever felt. They have all appeared, to me, to come on, as if a ſolid body, or a wave of earth, (if the expreſſion may be allowed) was rolling along under the ſurface of the earth ; which firſt raiſed that part which was over it, and then left it gradually to ſubſide : the conſequence of which was, a ſtrong *undulatory motion* of the earth ; which was immediately ſucceeded with an univerſal trembling, or very quick, jarring, vibratory motion, as though the earth was ſtruggling to recover its former poſition.

Another thing obſervable in the earthquakes of *New-England* is, they have all gone in much the ſame *courſe.* As to two or three of the earthquakes, we have no account of their *courſe :* but in all thoſe in which it was determined, there is a very great agreement. They are all deſcribed as coming from about north-weſt, and going off about ſouth-eaſt. As this was the caſe with all whoſe direction was obſerved, we may rationally conclude, that they all proceeded in pretty much the ſame general track ; in a path from about north-weſt to ſouth-eaſt, though with many ſmall deviations and irregularities, in particular places. This, if I do not miſtake, has not been generally the caſe in the earthquakes of other places. The great earthquakes which have ſpread deſolation in *Sicily*, *Peru*, and *Jamaica*, inſtead of proceeding in any regular courſe, are deſcribed rather as inſtantaneous blaſts, which ſtruck dreadfully upwards,—not proceeding in any certain tract, from one country to another ; but ſuch as burſt and rent a large circle of earth

all around. But with us, they have all proceeded in a different manner; and in a manner apparently regular;—fiercely driving along, as it were, in the same path, as though a passage had been opened for, or by them, from one country to another; in some places coming more near, and in others, running more remote from the surface of the earth. And the distance to which some, and probably several have run in the same course, has been greatly amazing;—nineteen hundred miles at least, and how much more we know not.

From the last remark it seems probable, that the earthquakes of this country, have had their *origin* at some considerable distance to the north-west of *New-England*, and possibly at much the same place. Whatever might be the case with those small shocks that have had but a small extent, or wheresoever they might begin, the larger ones have all been observed to come from the north-west; and they were of much the same violence at the most north-westerly settlements, as at other places in the country. The place, therefore, where they have had their *origin*, must have been in some part of the unknown lands which lie to the north-west of *New-England*; and probably at some considerable distance from any of the *European* settlements; as there has been no account from any of them, in which it had not the same direction, coming on from the north-west. Whether the great shocks have all originated at the same place, we have no way to determine; but from the agreement of their courses and motions, it seems not an improbable supposition.

There seems to have been a particular part of the continent of *North-America*, which has been the *seat* of the earthquakes of *New-England*, and to which they have always been confined.

To

To the ſouth-weſt, they have ſeveral times reached as far as *Maryland*; but never ſo far as *Virginia* or *Carolina*. To the north-eaſt, they have been bounded by *Nova-Scotia*; having never been felt much further than *Halifax*. From the unknown lands, at the north-weſt, they have gone off ſouth-eaſt, into the *Atlantic*: their extent this way, being greater than we are able to trace on either point of the compaſs. The province of *Maſſachuſetts-Bay*, or rather, that part of *New-England* which is about the latitude of 43° north, where the river *Merrimack* empties itſelf into the *Atlantic*, has generally been the centre, or place of their greateſt violeuce. If from this place, a line be drawn north-weſt, it will pretty well repreſent the central courſe of the earthquakes of this country: and from this line they have extended about four hundred miles to the ſouth-weſt and north-eaſt. It is not meant to be very particular, but only general, as to theſe boundaries.—And the whole country, within theſe limits, has been repeatedly ſhaken,—moſt violently about the middle, and leaſt ſo towards the ſouth-weſt and north-eaſt boundaries. As far as can be gathered from the accounts, it ſeems probable, that moſt of the great ſhocks have reached to much the ſame places: the ſmall ones, indeed, have not had ſuch an extent; being felt only in different provinces and towns. But *all* the earthquakes, within the above-mentioned limits, have come from the ſame point, and ran in the ſame courſe: the great ones reaching to much the ſame extent, as though there was ſomething to direct their motions the ſame way, and to confine them to the ſame limits.

With what *velocity* theſe earthquakes moved, it is not eaſy to determine. In many accounts of earthquakes, their motion has been ſaid to be inſtantaneous, like that of the electrical

ſhock. The reverſe has been the caſe in the earthquakes of *New-England*. Inſtead of being inſtantaneous, their motion has never been very ſwift. To compute, indeed, with accuracy, with what velocity any of them moved, we have no ſufficient *data*. Had the times at which any of them begun, been carefully noted at places whoſe diſtances were known, it might have opened the way to ſome very curious concluſions. But all the accounts, excepting one of Profeſſor *Winthrop*, are too general to form any certain inferences of this kind. There is, however, one article in the accounts of the earthquakes of 1727, 1755, 1757 and 1761, from whence we may conclude, that the *velocity* of their motion, was conſiderably leſs than that of *ſound*. Moſt of the accounts of the earthquakes of 1727 and 1755, agree, that the roar was heard at leaſt half a minute before the ſhake began. The ſound, therefore, that was occaſioned by the approach of the earthquake, preceded the ſhock with a motion conſiderably ſwifter than that of the earthquake itſelf. Now, *ſound* moves about thirteen miles in a minute; and the motion of this was conſiderably ſwifter than the motion of the earthquake. In the earthquakes of 1757 and 1761, the ſound was alſo heard half a minute before the ſhock was felt: and as the report was much leſs, and therefore could not reach ſo far as in the larger ſhocks, the inference will be, that theſe ſmall ſhocks moved with a velocity conſiderably leſs than the larger one. And, indeed, the ſuppoſition ſeems not improbable, that the *velocity* with which an earthquake moves, ſhould bear ſome proportion to its *violence*,—to the ſtrength and force of thoſe cauſes, by whoſe operation it is produced. Whether there does not ſeem ſome evidence that this has been the caſe with us, the reader will judge for himſelf, from what has

has been obſerved above. If this is the caſe, as I believe it is, future obſervations may determine it with much more certainty and preciſion, than any that have yet been made.

But although we are able to diſcern ſome appearances of agreement and ſimilitude in thoſe phenomena that have been mentioned, we cannot diſcern any in the *times* in which theſe earthquakes have happened. From their having all proceeded in the ſame courſe, one might be led to ſuſpect, whether their cauſes, whatever they are, operating in the ſame direction, would not require nearly the ſame intervals of time, to gather ſufficient force to produce the ſame effects. But nothing of this nature is apparent. The intervals of time, at which they have happened, have been very different, and without any apparent regularity. Not to mention the ſmaller ſhocks, there have been five which have been diſtinguiſhed by their being much larger than the reſt: thoſe, I mean, of 1638, 1658, 1663, 1727 and 1755. Between the two former of theſe, there was an interval of twenty-eight years.—Between the two next, an interval of five years: then one of ſixty-four; and between the two laſt, of twenty years. At a medium, this will make one in about twenty-ſeven years. But in theſe different intervals, there is no apparent order, regularity, or proportion, in the times of their happening. Neither does there ſeem to be any proportion between *the intervals of time*, and *the violence of the ſhock*. One would be apt to imagine, that the longer the cauſes were gathering ſtrength, the greater would be the violence of the earthquake when it came: and yet that of 1755 was greater than that of 1727, though the interval of time had not been half ſo long. It is to be obſerved, however, that as our accounts of the earthquakes are but imperfect, as to their

number,

number, and much more so as to the degree of their violence, all our reasonings, upon this article, must be very uncertain.—Nor could we, without very accurate accounts of the time and violence of the earthquakes, the smaller ones as well as the greater, state any proportion between the *times* and the *shocks*, supposing such proportions to exist. But if there are any such proportions, or any order and regularity, in their periods, it is not apparent; but rather the contrary, from all the accounts I have been able to collect.

It is also worthy of remark, that these earthquakes do not seem to have any *connection* with any thing that falls under our observation. It has been suspected, by those who account for the origin of earthquakes on the principles of electricity, and by many others, that there is some connection between the state of the weather, or rather atmosphere, and the happening of an earthquake. As our knowledge of this subject is so imperfect, it may not be amiss to note every thing of this kind. And it is observable, that the earthquakes have generally happened in calm, serene and pleasant weather. Some of the accounts are very imperfect in this respect: but, in general, they seem to agree pretty much in this particular. But though it has generally been the case, that the earthquakes have come on in fair and pleasant weather, it has not been universally so.—In the earthquake which happened November 22, 1755, after the great shock on the 18th, the whether was not clear and fair, but dull, cloudy, and attended with small showers, and a brisk gale at south-west.—And in March, 1771, there was a small shock, when, instead of being fair weather, there was a heavy storm of snow. But perhaps it is of no great consequence to mention this. It has been more common for writers on this subject to attempt

attempt to find ſome *preceding ſigns*, or forerunners, of theſe events. And in this reſpect, fear and ſuperſtition have been abundantly fruitful. Philoſophy has nothing to do with the many idle reports of this kind, that have prevailed among the vulgar. But among the many things that have been ſuppoſed to exiſt, there is one that deſerves our notice, as having, probably, a real foundation in nature. Ancient and modern writers have ſuppoſed, that it might in ſome caſes be a prelude to an earthquake, when the water, in deep pits, wells, caverns, ſprings, &c. is thrown into uncommon motions, diſturbed, altered and changed, as to its courſe, kind, or quality. It is rational to ſuppoſe, that ſuch events may, in ſome caſes, proceed from thoſe cauſes, which, in a little time, have burſt out, and rent the adjacent country. Some curious obſervations of this kind, were mentioned by Meſſieurs *Dudley* and *Allin*, as happening a few days before the earthquake of 1727: and ſomething of the ſame kind was obſerved previous to the earthquake of 1755. As theſe accounts have been mentioned,* it is unneceſſary to repeat them here. I am far from ſuppoſing, that any certain prediction of earthquakes can be generally made from ſuch obſervations; as ſuch events may, and no doubt do happen, without being followed by any ſhocks; and earthquakes often take place without any ſuch events. But at the ſame time, it can hardly be doubted but that the alterations obſerved in the water of theſe wells, was owing to the operation of the ſame cauſes, that in a few days burſt forth with ſuch violence as to ſhake all *New-England*. With regard to the *ill effects* that have ſucceeded earthquakes in ſome countries, it is well known there have been many and fearful accounts.

In

* Vide p. 265 and 277.

In some places, they are said to have been followed with great mortality, pestilential disorders, and the most raging sickness. Nor is it improbable, that the air should be infected with noxious effluvia, from the vapours that were before confined, and perhaps corrupted. It seems credible, that something of this nature has been the case, and, probably, the *consequence* of earthquakes, in some places. Many of these reports, indeed, seem to be much like what has been said of the effects of comets, meteors, and the conjunctions of the planets.—But at the same time it seems probable, both from ancient and modern accounts, that in some places, pestilential disorders have, in fact, and probably as the consequence, succeeded great earthquakes. Nothing of this nature has been the case in *New-England*. It is, however, highly probable, from the Rev. Mr. *Lowel's* observation,* that some very noxious vapour, or effluvia, attended the eruption of the earthquake of 1727: but no bad effects, no pestilential distempers, no sweeping sickness, or uncommon disorder or mortality, has been observed to succeed any of the earthquakes of this country; no otherwise, at least, than what has been common at other times.

CONJECTURES on the CAUSES of these EARTHQUAKES.

IN this enquiry into the Causes of Earthquakes, it is not my design to enter into a particular discussion of the several hypotheses philosophers have assigned, as accounting for the production of such phenomena.—I mean to consider the subject

* Vide p. 268

ject no further than it has relation to the earthquakes of *New England*, and what may be gathered, as to their causes, from the preceding HISTORY and REMARKS.

From the phenomena and observations that have been mentioned, we may safely infer, that the earthquakes of *New-England* have been produced by *something which has moved along under the surface of the earth.* Whatever may have been the case in other places, all the earthquakes of this country, so far as we have any accounts of them, have been of the same kind; consisting, not of a simple instantaneous vibration, like that of an electrical shock, but of a gradual heaving, swell, or undulation of the earth. This has moved along in much the same path, with a motion not very swift: and it has reached deep enough below the surface of the earth, to affect and disturb the fountains, springs, wells and pits of water. These phenomena, are effects, which would naturally lead us to conclude, that the causes, whatever they may be, had their seat, rise and operations under the surface of the earth. And this conclusion from the *phenomena*, is strongly confirmed from *observation*.—For the shocks have come on, rose to their greatest height, and gone off, to all appearance and observation, as if they had been occasioned by the rolling of some solid body under the surface of the earth. In this manner Professor *Winthrop* describes that which happened November 22, 1755:—"I was then," says he, "sitting on a brick hearth: and the "sensation excited in me, was exactly the same as if some small "solid body, by moving along under the hearth, had raised "up the bricks successively, which immediately settled down "again."* The same observation has been frequently made

 by

* Lecture on Earthquakes, p. 12.

by others; and is agreeable to all the accounts that can be collected. And from these accounts of the several phenomena of the earthquakes, and the observations that have been made upon them, I think we may lay it down as *a pretty certain fact*, that the earthquakes of *New-England* have been caused by something which has moved along under the surface of the country.

What thus moved under, and hove up the surface of the earth, was probably *a strong elastic vapour*. This is inferred from the phenomena that have attended the earthquakes.

Among these phenomena, there were some that preceded the earthquakes, and looked like a *previous preparation*. In the earthquakes of 1727 and 1755, in particular, it was evident, that the causes by which they were produced, were at work several days before they became ripe for an explosion. As tho' some grand fermentation was taking place in the bowels of the earth, the water, in several wells and springs, was uncommonly altered in its motion, colour, smell and quality. This was observed three or four days before there was any earthquake. Nothing could better agree with the origin and production of a subterraneous elastic vapour, than this circumstance. For however such a vapour be generated, by mixture, fermentation or fire, it would require some previous preparation, for its production, or before it would be collected in sufficient quantities to cause an explosion, or acquire sufficient force to move and shake the surface of the earth.

The *noise* or *roar*, occasioned by the earthquakes, has always been such as might have been expected from a subterraneous vapour, when fiercely driving along under the surface of the earth. What report might be expected from a strong elastic

vapour,

vapour, when its motion is confined and directed by a particular channel or paſſage, we may learn from that of a blazing chimney. The action of fire, when turning the inflammable materials, with which the chimney abounds, into flame and vapour, produceth a noiſe or roar of a very particular kind; and which ſeems to be different from almoſt any other: and there is nothing to which the report of our earthquakes is more ſimilar, or has been more often compared.

There is alſo an apparent agreement between the effects of a ſubterraneous vapour, and the *kind* and *motion* of the ſhocks. When the materials, from which a ſubterraneous vapour is produced, lie promiſcuouſly mingled and blended together, the effect of an exploſion would be a violent ebullition, or blaſt upwards; tearing and rending a circle of earth, all around. This ſeems to have been the caſe in the earthquakes of *Sicily*, *Lima* and *Jamaica*. When the vapours can have a regular diſcharge through any aperture in the ſurface of the earth, they will vent themſelves in copious effuſions and exhalations, and thus ſpend their force this way, as they gather ſtrength from time to time. Thus it has been with *Hecla* formerly; and with *Veſuvius*, *Ætna*, and other volcanoes now. But when the vapours are confined under the ſurface of the earth, and have ſubterraneous paſſages, or proper ſtrata, for them to run in, by the violence of their expanſion, they will heave up the ſurface of the earth, and thus cauſe, not an inſtantaneous concuſſion, but a progreſſive ſwell or undulation of the earth.—And this will be continued till the vapours, thus confined, find or force for themſelves a paſſage, where they may burſt from their caverns, and diſcharge themſelves into the open air.—

 And

And these are phenomena in all respects agreeing with those that have attended the earthquakes of this country.

The strength and force of such a vapour, would be sufficient to account for the *violence* of any shocks we have had. A very great force must be requisite to heave up, and cause a progressive swell in the surface of the earth, and this, perhaps, from some depth below.—And with what force subterraneous vapours may be attended, we may form some idea from their effects. In those which have shook *Vesuvius* and *Ætna*, it has been no uncommon thing to see them throw up at once, such clouds of sand, ashes and pumice-stones, as are capable of darkening the whole air, and covering the neighbouring country with a shower of dust, &c. to many miles distance. Great stones, also, of some tons weight, are often thrown to the distance of two or three miles, by such explosions. Mons. *Bouguer* tells us, that "he met with stones in *South-America*, of eight or nine feet diameter, that had been thrown from the volcano *Catopaxi*, by one of these blasts, to the distance of more than three leagues." In *Ulloa's* account, the whole plain, near *Latacunga*, is said to be full of pieces of rocks, some of which were thrown, from the same volcano, to the distance of five leagues.† If subterraneous vapours, when they have had nothing to confine them, have acted with such force, we may easily conceive that they must heave up, and cause a progressive swell in the surface of the earth, when their force was confined, and their motion directed by a particular passage.

The *eruptions* and *effusions* that have attended our earthquakes, have also borne strong marks of subterraneous vapour. That a vapour of sufficient force to shake and move the surface of a whole

† Phil. Trans. for 1760, p. 592.

whole country, ſhould break out in many places, where it came near to the ſurface of the earth, is agreeable to the preſumption of theory. Thus it has been with ſeveral of our earthquakes. In that of 1727, there was an eruption at *Newbury*, attended with an effuſion of ſand, containing ſmall mixtures of ſulphur, and a very noxious, ill-ſcented vapour. Strong ſulphureous ſmells were obſerved in other places; and, as ſome ſuppoſed, there were alſo appearances of flame. In the earthquake of 1755, there were eruptions at *Scituate*, *Pembroke*, *Lancaſter*, &c. with large effuſions of ſand, probably of a ſulphureous nature. Whether this was the caſe with any of the other earthquakes, the accounts are not particular enough to determine. But in theſe, both the matter and ſmell attending the eruptions, afforded ſtrong marks and evidence of ſubterraneous vapours.

The earthquakes of *New-England* have alſo made ſuch *alterations* in the bowels, and upon the ſurface of the earth, as a ſtrong ſubterraneous vapour would produce. Very conſiderable alterations might be expected in the bowels, and upon the ſurface of the earth, and in the ſyſtem of ſprings, fountains, currents and ſtreams of water, from a vapour of ſuch force as to break thro' the ſurface of the earth, and of ſuch extent as to reach from one country to another. Such effects have always followed the larger ſhocks. In that of 1663, incredible alterations are ſaid to have been made in the ſurface of the earth at *Canada*, for many leagues through the country. Rocks and mountains were, in ſome places, thrown down, and conſiderably removed; and the channel in ſome parts of the river *St. Lawrence*, was very much changed and altered. In thoſe of 1727 and 1755, the ſurface of the earth, in ſome parts of *New-England*, was conſiderably

considerably broken and changed; and the whole system of fountains and springs, was greatly affected. Great alterations were made in wells, ponds, fountains and currents of water: some were dried up, others opened; new ones produced, and, in many, the kind, quality and quantity of the water was greatly changed.—Alterations in all respects similar to what might be expected from subterraneous vapours, fiercely driving along under the surface of the earth, with a force sufficient to move and shake so large a part of its surface.

This opinion agrees also *with the effects which the earthquakes have had on the water*. The earthquakes of *New-England* have been felt not only upon the land, but also upon the sea. Several vessels, which have been upon the coasts at the times of the larger shocks, have been very sensibly affected. To the people on board, the shocks seemed as if the vessel had struck upon a rock; or rather, as if something had thumped against their bottoms. This, it is probable, was the very case; and is agreeable to what might be expected from the operation of subterraneous vapours.

The earthquakes moved with a velocity sufficient to communicate the same kind of motion to the water that they did to the earth; and thus caused a very deep, large and extensive swell or wave. This wave, arising from the bottom, rolled along with much the same velocity as the earthquake moved: the effect of which, when it came to a vessel floating upon the water, would be a very considerable stroke or thump against the bottom,—more or less violent, according to the violence of the shock, and the depth of the water.—And in this manner have vessels, upon the coast, been affected;—some scarce perceiving it; others not at all; while to others it was pretty violent.

There

There have been other effects upon the water, ſuch as a ſurpriſing flux and and reflux of the ſea,—extraordinary agitations and commotions of the waters,—an uncommon deſtruction of fiſh, &c. Theſe effects have not been common, and never but at a conſiderable diſtance from the coaſt of *New-England*. And they ſeem to be plain and evident marks and effects, of the diſcharge of the ſubterraneous vapours, at the bottom of the ſea. Such a diſcharge, when ſmall, would be ſufficient to occaſion the deſtruction of ſuch fiſh as were near it : and when large, would put an end to the earthquake, and produce the moſt extraordinary agitations and commotions of the ſea, by a furious eruption of vapours at its bottom ; which would immediately force their way through, or carry up before them, the whole body of water that lay over them.

And thus as to the *concluſion* :—It might be naturally expected, that as the vapours, by which the earthquakes were cauſed, were ſome time in growing ripe, fermenting, or in a ſtate of previous preparation, they would not be wholly ſpent or diſcharged at once, but leave ſmall remainders at particular places. Thus it has proved in all the great earthquakes we have had. The vapours, by which they have been produced, have not been wholly ſpent at the firſt ſhock : but what has remained, and what has gathered after a great exploſion, has produced various ſmall ſhocks in ſeveral places, for ſome time after the great ones :—thus waſting and evaporating by little and little, as they were collected and prepared at firſt ; till, by degrees, all has become quiet again.

Such have been the phenomena that have attended the earthquakes of *New-England*.—And to me, they appear to be ſuch, as (viewed either together or apart) make it highly probable, that

that what moved under, and hove up the surface of the earth, was *a strong elastic vapour*.*

The *origin* or *production* of such a vapour, may be accounted for from the CONTENTS of the earth. Much the largest part of the contents of the earth, will always remain hidden from our view, and beyond the reach of our knowledge. We have, however, penetrated far enough below its surface to find, that many of the bodies it contains, are of such a texture, or contain particles of such a nature, as to generate, or be easily turned into vapour. This is the case with coals, salts, sulphur, nitre, air, water, most kind of minerals, and all substances which contain oily particles. Such bodies, at least some of the particles they contain, are easily and often turned into a very strong, subtle, elastic vapour. With some, nothing more is necessary to generate a very powerful vapour, than a bare *mixture* of different bodies. Thus equal quantities of powdered sulphur and iron filings, being mixed with water, soon become too hot to be touched; and in a little time emit flame and vapour. And if iron, oil of vitriol, and water, become mixed together, there will instantly arise a violent ebullition, with fumes copiously exhaling; and which are so very inflammable, that if set on fire, they go off at once with a loud explosion. The same is also effected by *fermentation*. Instances of very strong elastic vapours, produced this way, are so common and obvious, that particular cases need not be mentioned. All separable, mixt and compound bodies, may be the subject of this operation: and the easier they are separable, whether by means of

* From the phenomena which have been mentioned, it seems probable, that this elastic vapour was a fluid, of the same nature as that which is now called *inflammable air*.

of water, air, or heat, the more readily they ferment.—And when they do ferment, they will produce a vapour more or leſs ſtrong, according to the quantities of the fermenting matter, and the degree of the fermentation. But in no method is a more powerful vapour produced, than by *fire*. What an amazing effect will a ſmall ſpark of this have on nitre and ſulphur, when made up into ſuch a compoſition as that of gun-powder! How ſmall a quantity of this powder, when on fire, will generate a vapour of ſufficient force to burſt the firmeſt rocks! Air, by the application of fire, becomes ſo elaſtic, as to break through all oppoſition.—And there are many effects produced by the vapour of water, when intenſely heated, which make it probable, that the force of gun-powder is not near equal to it. And, in general, all combuſtible bodies are capable of being turned into vapour, by the action of fire.—And fire ſeems to be a fluid, which is ſpread through almoſt all bodies whatſoever. It certainly exiſts, in very large quantities, in the bowels of the earth.—Some parts, as the volcanoes are actually burning, and have been throwing out fire, flame, ſmoke, cinder, rocks and lava, for many ages.—And where there are no ſuch appearances of it, it exiſts, and is diffuſed in great quantities. That this is the caſe is evident from hot ſprings,—the warmth that is always found in deep mines and pits,—and thoſe burning mountains that have been thrown up from the bottom of the ſea.—And when collected into large quantities, its effects on water, air, the fumes of fermenting minerals, and all kinds of combuſtible bodies, would be to generate a vapour more or leſs ſtrong, according to the quantities of the minerals of which it was compoſed.

Thus, in the *contents* of the earth, we find sufficient materials for the production of the most strong, active and powerful vapour;—and such materials as do, in fact, produce most terrible volcanoes,—vapours that have hove up, and broke thro' the surface of the earth,—and earthquakes that have shaken the whole country, for twenty miles around *Vesuvius* and *Ætna*. —And such explosions and concussions are what all those countries are subject to, which abound with sulphur, nitre, and such combustible materials.

As the *contents* of the earth will account for the *origin*, the *structure* of it will account for the *motion* and *direction* of a subterraneous vapour. Were the globe a perfect solid, there could be no motion of a subterraneous vapour under its surface. But this is not the case.—Instead of being a perfect solid, the earth is of a *cavernous structure*; containing various pits, holes and caverns. Some of these are dry; others are the fountains, or contain currents of water; and others abound with the fumes of fermenting minerals, and with various kinds of vapour and effluvia. That the earth is thus of a cavernous structure, is evident from the mines, springs, and currents of water, that are found below its surface, in every country, and in almost every place. And it is probable, that many of these subterraneous caverns may be of a great extent;—some running in a direct, and others in long, crooked, unequal passages. —And by thus winding, meeting, crossing and mixing with each other, they may form communications between very distant parts of the earth. The *manner* in which the solid and fluid parts of the earth are *disposed*, is also worthy of remark.—In some places, they are found promiscuously mingled and blended together, in a manner which has no apparent order

order or regularity. In other places, the various kinds of *solids* appear to be disposed with the utmost apparent regularity, in the form of different and distinct *strata* of clay, coals, salts, sulphur, minerals, &c. It is thus also with the *fluids*;—in many places, they are regularly collected into quantities, or fountains, within the bowels of the earth; in others, they are constantly and regularly moving in perpetual streams and currents: some of which are charged with sulphureous particles; others with those of iron; and others, with various other tinctures and mixtures.

And from this *Structure* of the earth, *the motion* of a subterraneous vapour would receive *its direction*. For vapours, generated and increasing in the bowels of the earth, if they found no vent upwards, must naturally take their course and rush fiercely along under the surface of the earth, according as they found subterraneous *passages* or *strata*, of proper materials to conduct them.—And it seems as if something of this nature must be the case in this part of *America*. That there should be a particular part of the country, as to width, to which the earthquakes of *New-England* have repeatedly reached; that they should all be of the same kind,—come from the same point,—and proceed in the same path;—these phenomena cannot be supposed to be the effect of what is called chance or accident. It is evident there must have been something which served as *conductors*. If *subterraneous passages*, of such extent as these earthquakes, should be admitted, it would be difficult to account for the width of the earthquakes, on that hypothesis. The more probable supposition seems to be, that there are some particular *strata*, which have served as fuel or conductors to the vapour. And that this was the case, seems further probable from the

 sulphureous

sulphureous mixtures that have been thrown out at the different eruptions. Instances of these eruptions are mentioned in the accounts of the earthquakes of 1727 and 1755.—And they are such as make it probable, that there is some particular *stratum* under the surface of the country, which has served and will serve to direct the motion of the subterraneous vapour, from the places of its origin, to that of its grand final eruption.*

On this account of the Causes of the Earthquakes of *New-England*, it may not be amiss to remark, that part of it seems to be matter of *fact*, and part matter of *conjecture*. As the causes lie out of sight, and beyond the reach of observation, we have no way to come to the knowledge of them, but by general reasonings from the phenomena that fall under our observation. These phenomena, I may venture to say, have been fairly related :—but whether the inferences that have been drawn from them, are just,—the conjectures, such as are probable,—the conclusions, well supported,—and the evidence, such as might

* Such *strata* are not at all uncommon. Many countries are known to abound with, and to be distinguished by them. "We have an instance of it in the chalky and flinty countries of *England* and *France*, which (excepting the interruption of the channel, and the clays, sands, &c. of a few counties) compose a tract of about three hundred miles each way." Phil. Transf. for 1760, p. 587. The volcanoes in the *Andes*, are in all probability derived from the same *stratum* of combustible minerals ; the extent of which cannot be less than five thousand miles,—for so far do the mountains and volcanoes extend.—And thus in *North-America*, if we may give credit to *L. Evans*, in descending from the mountains which adjoin to the western lakes, the same sets of *strata*, and in the same order, are generally kept up.

In some countries, earthquakes have ceased upon the breaking out of volcanoes. If there were volcanoes in this part of *America*, which might serve to interrupt the *stratum*, and as a vent for the subterraneous vapours to discharge themselves, it is probable the earthquakes of *New-England* would not run in such a regular manner, through such an extent of the country.

might have been expected,—these are submitted to the judgment of others. Hypotheses may be of use to put us upon further enquiry, and a more critical examination; but are never to be received, any further than they are supported by proper evidence.

GENERAL REFLECTIONS on EARTHQUAKES.

THE preceding ACCOUNTS, OBSERVATIONS and CONJECTURES, have been confined to the earthquakes of *New-England*.—But they will naturally lead us to some GENERAL REFLECTIONS on the nature, use and effects of these formidable phenomena. Thus,

If we are right in our conjectures on the causes of earthquakes, we may conclude, that the globe always has been, and will be subject to such concussions. From the earliest ages, of which we have any accounts, this has been the case. Many parts of the earth bear the marks of great and furious eruptions; not a few of which, were prior to all historical monuments and records. The eruptions of the noted *Ætna*, may be traced back an hundred years before the siege of *Troy*.* *Vesuvius* was a volcano before the foundations of *Herculaneum* and *Pompeii* were first laid. These cities were covered by an eruption of *Vesuvius*, A. D. 79. Their foundations and pavements are all of that melted and vitrified substance called *lava*, which *Vesuvius* had thrown out;—which is a proof of great eruptions, prior to the foundations of these cities.† How long these volcanoes, or those in *Iceland*, the *East-Indian* islands, and

* According to M. *D'Orville*.

† Phil. Transf, for 1771. Art. 1.

and *South-America*, have been burning, we have no hiſtory or tradition ancient enough to inform us. Many of their effects bear the marks of more furious eruptions than any there have been in modern times. The ſoil for more than twenty miles, round *Naples*, by its cinder, ſtones, burnt matter and lava, appears to have been the production of very ancient ſubterraneous fires, earthquakes and eruptions.* The *Appenines*, a chain of mountains which divide the continent of *Italy* from north to ſouth, and extend even to *Sicily*, diſcover many tokens of an internal fire; and were judged, by that celebrated philoſopher, M. de la *Condemine*, to be a chain of ancient volcanoes. This is alſo the caſe with that long chain of mountains in *South-America*, known by the name of the *Andes*. Theſe mountains run from 45° ſouth latitude, to ſeveral degrees north of the line, and alſo throughout all *Mexico*; being, according to Monſ. *Bouguer's* account, five thouſand miles in extent. The ſeries of volcanoes, formed by theſe mountains, is interrupted: many are totally extinguiſhed; and there are many which are ſtill burning; and many of the ancient ones frequently burſt out again.‡ Several of the *Weſt-Indian* iſlands, the *Azores*, *Teneriffe*, and moſt high mountains, either contain volcanoes, or, by the veſtiges of calcination and vitrification, ſhow the former effects of them.—And as ſeveral iſlands and mountains have been ſunk, ſo we have authentic accounts of ſeveral that have been thrown up from the bottom of the ſea, by ſubterraneous fires. Such effects with the relations of hiſtory, afford plentiful evidence, that the globe has always been ſubject to and greatly affected by ſubterraneous fires, earthquakes and volcanoes. The

* Phil. Tranſ. for 1771. Art. 1.

‡ *Condamine's* Travels into *Italy*.

The ſame cauſes which have produced ſuch effects on the ſurface, are undoubtedly ſtill exiſtent in the bowels of the earth. Proper periods of time may be requiſite for them to grow ripe, or gather ſtrength ſufficient to cauſe an exploſion or earthquake. But as the materials from which ſubterraneous vapours are formed, conſtantly exiſt in the bowels of the earth, they will be as conſtantly fermenting; and thus increaſing the quantity and force of the vapours, till they ſhall become ſufficient to break through all oppoſition, and force for themſelves a paſſage thro' the earth. And although they may in ſuch ways be diſcharged from time to time; yet, ſo long as the ſame powers ſhall ſubſiſt in matter, new vapours will be produced; and, of conſequence, the ſame effects, after proper intervals of time, will again take place. Nor are they to be viewed as marks of any diſorder or irregularity in the works of nature. For,

Notwithſtanding all their terrible effects, earthquakes ſeem to be a neceſſary conſequence of ſuch laws of nature, and powers in matter, as are, upon the whole, greatly beneficial to the globe. There is no phenomena in the whole courſe of nature, ſo formidable as that of an earthquake.—Nor is there any that has ſpread more univerſal horror, calamity and deſolation. Hiſtory, ancient and modern, abounds with accounts of large countries that have been ſhaken,—whole cities that have been ſunk and covered,—and immenſe numbers of mankind that have been deſtroyed, by theſe dreadful convulſions of nature. In the earthquake which ſhook *Sicily*, in the year 1693, fifty-four cities and towns, with an incredible number of villages, were either deſtroyed or greatly damaged, and about ſixty thouſand perſons periſhed. In that at *Jamaica*, in 1692, almoſt the whole of *Port-Royal* was ſwallowed up, and large numbers of

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its inhabitants buried in its ruins.—And in the earthquake at *Lima* in *Peru*, in 1746, all the buildings in that city, and in the port of *Callao*, except about thirty, were ſunk, or laid in ruins, and great numbers of people deſtroyed :—four hundred and fifty-one ſhocks, many of which were equal to the firſt, ſucceeding in the ſpace of four months. The deſtruction of *Liſbon*, by the earthquakes in 1755, was alſo attended with the moſt tragical ſcenes of deſolation, death and miſery. And yet, notwithſtanding all theſe dire effects of earthquakes, it is very poſſible, that the laws and cauſes from whence they ariſe, may be a neceſſary proviſion, and a real advantage to the globe. The power of gravity, the wind and water, rain, heat and cold, have occaſioned the deſtruction of vaſt numbers of mankind : and yet they are a general advantage to the earth, and to its inhabitants ;—and ſuch an advantage, that no creature could live on this globe without them. And ſince they produce an *over-balance* of good, they are to be eſteemed advantageous and beneficial upon the whole ; although in ſome particular caſes, they may be attended with very dangerous and fatal effects. This, it is probable, is the caſe with all the laws, powers and operations of nature ; and to all thoſe agitations and concuſſions to which the earth is ſubject.

To enumerate all the ends to which theſe formidable phenomena may ſerve in the natural world, would require higher degrees of knowledge than it is probable we ſhall ever have of this ſubject. And yet, perhaps, we may ſee enough to convince us of the wiſdom and benevolence of the Creator, in making the globe ſubject to ſuch concuſſions. Theſe extenſive and powerful agitations tend to weaken the attraction, looſen the parts, and open the pores of the earth ; and thus to fit and prepare

prepare it for the purposes of vegetation, and for the various kinds of produce that are necessary for the support of animal life. Were an insuperable bond of attraction to take place on the surface, or in the bowels of the earth, without something to oppose its power,—fluidity, motion, vegetation, and all nature would be at a stand. The power of gravity tends to this: And hence we find it necessary, by the operations of agriculture, to break the surface of the earth, to loosen its parts, and open its pores, and thus weaken its attraction, that it may be fit for the production of such fruit and grain as we want in the course of the year. An earthquake performs that in the bowels of the earth, which the various methods of agriculture perform on its surface.—And it is probable, that the former is equally necessary to the purposes of vegetation, as the latter.—And what seems to confirm these conjectures, it is observable, that those places which are most subject to earthquakes, are the most noted, *cæteris paribus*, for the fruitfulness of its soil, and the plenty of its produce. Thus *Italy*, *Peru*, *Manilla*, and especially *Ætna* and *Vesuvius*, places greatly subject to earthquakes, are celebrated for an uncommon fertility. There are other important ends which may be answered by earthquakes. Those subterraneous vapours, by which they are caused, seem necessary to prevent the inward parts of the earth from becoming too dense, compact and hard, in consequence of their attraction.—And when these vapours are collected in large quantities, it may be necessary to have them discharged into the atmosphere, to prevent a dissolution of the globe through the force of their elasticity or repulsion. It may also be necessary to have new subterraneous passages opened,—old ones diverted from their former courses,—and new communications establish-

ed between different countries,—that all parts of the earth may be ſupplied with ſuch kinds and quantities of water and air, as the growth of bodies, in the bowels and upon the ſurface of the earth, may require; and that the ſolid and fluid parts of the earth may be kept in their due place, connection and order.—And, in general, we may preſume, from the analogy of nature, that there may be, and no doubt are, many ends and uſes to which ſubterraneous fires and earthquakes may ſerve, of which we have as yet no ideas or conjectures. But however theſe things may be,

It is probable, that our knowledge of this ſubject will increaſe, as all other branches of natural knowledge have done, and by the ſame means, obſervation and reaſoning. In the contents and ſtructure of the globe, the Creator of it ſeems to have made proviſion for the production of ſubterraneous vapours and exploſions. Earthquakes may of conſequence be expected, at proper intervals of time, in every country and climate, ſo long as the earth ſhall continue to exiſt in its preſent form. As theſe events happen, poſterity will have opportunity to examine their phenemena, to note their effects and operations, and to mark all their differences and agreements: and, of conſequence, they will be obtaining more and more inſight into their nature, cauſes and effects. The methods of reaſoning which are now happily introduced into philoſophical ſubjects, though their effects may be ſlow, are yet certain and progreſſive. Every age will be doing ſomething for the next.—And the ſeveral philoſophical ſocieties already eſtabliſhed, by collecting and recording obſervations, are, and will be, providing materials for the ages that are to come.—And when a ſufficient number of obſervations ſhall be thus collect-

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ed, inferences may be drawn, and conclusions may be formed from them, of which, as yet, we have not the least thought or suspicion. It has been thus in all other branches of philosophy: and the same accuracy of observation and reasoning, when applied to the philosophy of earthquakes, will probably bring to light things, of which we have now no knowledge or conception.

From any knowledge we yet have of the nature and causes of earthquakes, nothing would appear more romantic, than to attempt to predict when such formidable concussions will happen. We know so little of their causes, much less when these causes will have collected sufficient force to burst forth and shake the adjacent country, that we have no way to form any rational conclusions as to the time when an earthquake will happen, from any inferences founded on the knowledge of the nature and operations of their causes. Nor can we receive much, if any, help from any *preceding signs*:—I do not mean those which fear and superstition have formed; but from any regularity of their periods,—state of the atmosphere,—uncommon motion of wells, springs, and the like.—For if there is any connection between things of such a nature, and the happening of an earthquake, it is what we do not understand.

But our ignorance of these things ought not to be made an argument, that there is not in reality any regularity or order in these events; or that it will always be impossible to discover so much of the nature and operations of natural causes, as to discern the same simplicity, order and harmony, in the several phenomena of earthquakes, as are apparent in many other works and operations of nature. In all those works of nature, of which we have any tolerable conceptions, stated laws, and a

 steady

ſteady regard to them, have been obſerved.—And this has been manifeſt and apparent in the ſame degree as our knowledge of any ſubject has been advanced. There was a time when univerſal confuſion and diſorder were ſuppoſed to prevail in the courſes, motions and appearances of the heavenly bodies. But as the knowledge of the true aſtronomy increaſed, the moſt perfect order, harmony and proportion has been diſcovered in the motion and appearance of every ſtar, planet and comet.—And it is now well known, that all the ſuppoſed irregularity in any of theſe bodies, was nothing more than want of knowledge, and confuſion of ideas in the obſerver. If we may reaſon from analogy, the concluſion will be, that it is the ſame in all other caſes. It can hardly be doubted, therefore, but that there is the ſame harmony, rule and order,—the ſame general and ſtated laws, in the cauſes and operations of earthquakes, as there are in all other events of nature. No reaſon can be aſſigned why theſe alone, of all the works of GOD, ſhould be made up of irregularity and confuſion. It muſt, therefore, be ſuppoſed, that earthquakes (like all other events that depend on natural cauſes) are ſubject to certain and determinate laws and rules, which are in themſelves conſtant, regular and harmonious,—whether theſe laws, or this regularity, is known to us or not.

The ancient *Egyptians* and *Chaldeans*, by a long courſe of obſervations, are ſaid to have been able to foretell the appearance of comets, and the approach of earthquakes.* The greateſt philoſophers have ſuppoſed their predictions of this kind were founded not on any knowledge they had of the laws and powers of nature, but on the vain arts of judicial aſtrology. This might be the caſe.—It is, however, to be wiſhed, that we could

* *Diod. Siculus.*

could be a little more certain what knowledge the *Egyptians* pretended to in this matter. It is well known, that the ſciences were much cultivated among that diſcreet people. Geometry and aſtronomy, if they were not begun, received very great improvements from them. The *Greeks* had all their aſtronomical learning from *Egypt*. *Pythagoras* got the knowledge of the true ſyſtem of the univerſe from the *Egyptian* prieſts.—And their advances in ſeveral parts of the mathematics, were great and uncommon. How far they were acquainted with the aſtronomy of comets, I am not able to ſay. Some of the *Chaldeans*, and *Pythogorian philoſophers*, taught many things as to the nature, orbits and revolutions of comets; which, though long diſregarded, modern aſtronomy has adapted, and abundantly confirmed.* And that there was nothing impoſſible,—nothing romantic, in attempting to predict their appearance, the great *Halley* has fully demonſtrated. And whether they might not have ſome knowledge as to the philoſophy of earthquakes, which, thro' the ignorance and barbarouſneſs of after ages, might be loſt to the world, ſeems worthy of enquiry.

But however this may have been, it is at leaſt poſſible, that regularity, order and laws may be diſcovered in theſe, as well as in other works of nature. It is, indeed, but very little that is yet known of the nature, cauſes and operations of theſe events. It will, probably, require the obſervations of many ages to digeſt and form them into a proper ſyſtem.—And a long courſe of obſervations may open new ſcenes to poſterity, and enable them to form concluſions,—I had almoſt ſaid *predictions*,—which to us would appear wild, abſurd and ridiculous: To me there appears as much ground for ſuch a conjecture, as *Seneca*

* *Gregory's* Aſtronomy. Book v. ſect. 1.

neca had ſeventeen hundred years ago for his, relative to comets; but which has literally been fulfilled.* But leaving theſe things to the ages that are to come,—

From contemplating theſe mighty works of nature, a philoſophic mind will naturally riſe in admiration and reverence, to the FRST GREAT CAUSE OF ALL! In all the works of nature, we find plain marks of that wiſdom, power and goodneſs, with which the whole plan, frame and conſtitution of it, was firſt formed and adjuſted. As all natural effects take place in conſequence of cauſes and laws derived at firſt from GOD, true philoſophy agrees with the holy ſcriptures, in aſcribing all ſuch events to his agency. It was no doubt with a view *ultimately* to *moral* purpoſes, that the laws of nature were firſt eſtabliſhed: and nothing can be better adapted than many of their operations, to awaken and direct the attention of mankind to the ſupreme Governor of the world. By the operation of natural cauſes, the Deity often 'ariſeth to ſhake terribly the 'earth.' 'He looketh on the earth, and it trembleth: he 'toucheth the hills, and they ſmoke.' 'He removeth the 'mountains, and overturneth them in his anger.' 'The pil- 'lars of heaven tremble, and are aſtoniſhed at his reproof.'

Amidſt ſuch convulſions of nature, ſtrong impreſſions of the power and majeſty of GOD, will naturally take poſſeſſion of the human mind. Mankind will ſee and feel their dependence upon their Creator,—with the wiſdom, benefit and advantage of

* 'A time,' ſaid this excellent philoſopher, 'will come, when thoſe things 'which now lie hid, will at laſt be brought to light, by length of time and the 'diligence of poſterity: for it is not one age that is ſufficient to make ſuch great 'diſcoveries.' *Seneca*, Nat. Queſt. lib. vii. chap. 25. May we not venture to ſay the ſame of earthquakes?

of ſuch a ſteady courſe of virtue, as leads to an habitual truſt in his providence and protection. Such unuſual and great events will powerfully awaken their attention to *morals*, and thus promote the advantage, although it may occaſion loſs and terror to mankind.

To pretend to be above fear, or to attempt to be unmoved with ſuch concuſſions of nature, would argue, on the one hand, a folly or a pride unworthy a philoſophic mind: and on the other, to give way at every ſuch event, to ſuch confuſion of thoughts and paſſions, as leaves no command over the mind, is a weakneſs as much as poſſible to be avoided. Of this we may at all times be certain,—the preſent frame of nature will ſubſiſt ſo long as Infinite Wiſdom and Goodneſs ſee it to be fit.—And no event will ever take place in the natural world, which was not foreſeen by him who is the AUTHOR OF NATURE, and deſigned to anſwer ſome wiſe and benevolent purpoſe. Of his favour mortals may be ſure, ſo long as they maintain a ſteady regard to the rules of virtue. This will always be productive of ſafety and happineſs; though the immediate effect of the preſent convulſions of nature, will probably be as the poet ſays,

Terra tremit: fugêre feræ, et mortalia corda
Per gentes humilis ſtravit pavor.

IX. *An Account of* West-River Mountain, *and the Appearance of there having been a Volcano in it. In a Letter from* DANIEL JONES, *Esq;* *of* Hindsdale, *to the Rev.* JOSEPH WILLARD. *President of the University at* Cambridge, *V. Pres. A. A.*

Hindsdale, *November* 2, 1783.

SIR,

I RECEIVED your's of the 18th of August last, and observed the contents: and as I am not only willing, but desirous of doing all in my power to aid the literati in their pursuit of knowledge, immediately upon the receipt of your letter, (altho' I have often been upon *West-River Mountain)* repaired there again, with the best guides, and thoroughly explored the same.

The Mountain is situate about twelve miles north of *Massachusetts* line, on the east side of, and adjoining *Connecticut-River*, in the county of *Cheshire*, and state of *New-Hampshire*, and opposite the mouth of *West-River*, from which its name arises.

The Mountain, in all its parts, contains about three thousand acres of land, and is very uneven. The south and west ascents, very steep: the north and east not so steep, but very ragged.

On the south side of the Mountain, about eighty rods from the summit, there has been an eruption,—perhaps not within the present, or last century. The peasants, in the neighbourhood of the Mountain, discovered this place, and became possessed with the idea of gold dust being in the Mountain, and that it melted down into a solid body, by the extreme heat of the

the Mountain, at the time the eruption happened : in consequence of which, they went to work in search of the supposed treasure ; and after fruitless searches, formed larger connections, entered into covenant with the proprietors of the land, and with one another, to make search for all kinds of mine and mineral. They have dug down about seventy or eighty feet ; and in some places, where the rocks permit, twenty feet wide ; but they are now impeded by the rocks, and the water that comes from the Mountain above the hole. The external parts of the hole is entirely rock, and in many places much burnt and softened. There are small holes in various places of the rock where they dig, like the arch of an oven, and the rock seems to be dissolved by heat ; the cinders and melted dross adhere to it, and hang down in drops like small icicles, something resembling in colour, the cinders of a furnace, or black glass, and it is so fastened to the rock, that it appears as if it was originally part of the same.

They dig out of the hole, near the surface, various strata of earth, or mineral ; and in digging a drain to let out the water, they find a great plenty of the same kind of earth ; and as it lies in the ground, the different complections are very curious to observe : there is a very fine soft yellow-oker, which, burnt, makes a good Spanish brown ; there is another strata, resembling levigated antimony, the particles very soft ; another of a faint yellow, fine, soft, and very greasy, which quality is not lost by lying on the surface of the earth, for a long time, exposed to the sun and air ; there is another that resembles a peach blossom in colour, but the texture more like the oker : and these various mineral, or earth, are not intermixed. At the mouth of the hole, there was blown out melted dross, which stuck to

the rocks ; and in the hole was found various pieces of ſtone, which appeared to be diſſolved by fire, and the ſides of the rock blackened by fire ; ſo that this hole muſt have been filled up ſince the eruption took place.

The miners inform me, that in the morning they frequently obſerve upon the earth that has been thrown out, ſomething very white, and by touching it with their tongue ſuppoſe it to be ſalt-petre.

In my late ſearch, I went to the top of the Mountain, directly above the place where the before-mentioned eruption happened, to ſee if there was a crater. The peak is ſmall, and there are about twenty rods of ground on the ſummit, which is rather hollow, where water ſtands in a wet ſeaſon (as is common in mountainous countries) but no regular crater. The hollow is oblong, and would have been, propably, had there been a great volcano (unleſs the heat had been ſo intenſe as to have diſſolved a prodigious ridge of ſolid rock, about fifty feet to the weſt of this hole) ſo to the top of the Mountain, which forms one ſide of a large dingle, from the top to the bottom of the Mountain, four or five hundred feet perpendicular ; where immenſe quantities of rock have fallen down, occaſioned, probably, by exploſions in the Mountains, or earthquakes. That there have been various exploſions in the Mountain, is beyond a doubt, and in various places, which have occaſioned great quantities of ſtone and rock to fall from the Mountain ; but I am inclined to think theſe exploſions are not frequent, as formerly, even fifty years ago ; for I am told by ancient people of veracity, who formerly dwelt at *Fort-Dummer* (oppoſite the Mountain) that there were frequently exploſions, and fire and ſmoke were emitted.

The

The last explosion that I recollect, happened about five or six years ago, the noise resembling that of an earthquake, and the earth trembled considerably where I was, about four or five miles from the Mountain; my herd of cattle were greatly terrified thereby, and run together through fear.

That there has been something more than a sudden explosion, every one that views it must be convinced: but that there has been any considerable volcano, so as to cause the earth above to fall in or settle, no one, I presume, will pretend.

I am, Sir, with great respect,
your very humble servant,
DANIEL JONES.

The Rev. JOSEPH WILLARD.

X. *An Account of Eruptions, and the present Appearances, in* West-River Mountain. *In a Letter from Mr.* CALEB ALEXANDER, *of* Northfield, *to Mr.* CALEB GANNETT, *Rec. Sec. A. A.*

Northfield, *May* 18, 1779.

SIR,

ACCORDING to your desire, I have visited the volcano upon the height of *West-River Mountain*, and shall do myself the pleasure to inform you concerning the various reports and particulars, relating to this place.

How long since it was first discovered, I am not able to ascertain. An old gentleman informs me, that fifty years since, he heard noises on that Mountain, as loud as the explosion of a great gun. Some years after, similar noises were heard, at the distance of fourteen or fifteen miles. Several times very violent eruptions of fire have been seen, the flame ascending very high into the air. Once in the winter there was an eruption. The years when the preceding eruptions happened, I cannot inform: the last was twenty-seven years since, which was the most violent eruption ever known in that place: it was towards the close of a dark evening, when it was first perceived, being preceded by a louder noise than common; then directly was seen the fire, which was seen to burn for several hours.

What I have written is by information: yesterday I was at the place myself. It is nearly upon the top of a very steep craggy mountain: by observation, I apprehend there were two places where the fire issued out; one of which is between two solid rocks, nearly a foot in diameter, but almost filled with the calcined matter caused by the fire, part of which appears simi-

lar

lar to burnt ſand, intermixed with cinders. The ſurface of the rocks, for a conſiderable diſtance, indicates that there have been very intenſe fires, and probably melted matter upon them, for they are turned into perfect cinders.

The other place where the eruption has been is ſo deſtroyed, that I can inform but little with regard to it: only upon one ſide the rock is greatly calcined.

A number of gentlemen, apprehenſive that there is ſome valuable mine in this Mountain, have undertaken to penetrate the bowels thereof. Accordingly, they have dug nearly eighty feet, in a perpendicular direction, into the Mountain, following a vein of matter, appearing ſimilar to oker, both yellow, red, and brown; alſo, very often, they find pieces of cinders, like thoſe which I have ſent you. This vein, in ſome places, is fixteen feet in diameter, in other places not more than five.

In digging, they often find ſtrata of this calcined matter, with a conſiderable mixture of other ſubſtance, appearing as if it had been intenſely burned. I deſcended to the bottom of this (truly hideous) pit, and obſerved, that the rocks, in many places, were turned into cinders.

I am not able to determine, whether there be any thing of a ſulphureous nature on this Mountain; but this I dare affirm, that there have been ſeveral eruptions: but whether it may, with propriety, be called a volcano, I know not. This determination is ſubmitted to the judgment of gentlemen more acquainted with the nature of volcano's, than I can pretend to be.

I ſend you, for obſervation, two pieces, that were taken one from the top and the other ſeventy feet under ground.

I am, &c.

CALEB ALEXANDER.

XI. *Obſervations made at* Beverly, *Lat.* 42° 36′ *N. Long.* 70° 45′ *W. to determine the Variation of the magnetical Needle. By the Rev.* JOSEPH WILLARD, *Preſident of the Univerſity at* Cambridge, *V. Preſ. A. A.*

AN attention to the variation of the magnetical needle, it is well known, is of great importance at ſea, nor is it of ſmall conſequence upon the land; eſpecially in *North-America*. From the firſt ſettlement of this country, the lines between towns, and between lots of land appropriated to individuals, have been determined by the magnetical needle. If the variation always continued the ſame, no difficulty would enſue, in again tracing the lines, upon the ſame magnetical courſe; but as it alters from time to time, the lines run in any ſucceeding years muſt deviate from the firſt, and from one another, unleſs proper allowances are made for the alteration.

From the want of a ſufficient number of obſervations, and of attention to this ſubject, in thoſe who have ſurveyed the lands in this country, difficulties have ariſen at one time and another, between towns and individuals. To remedy this inconvenience for the future, this Academy, ſome time ago, recommended magnetical obſervations, to determine the variation, which it is to be hoped will be made in various parts of the country, and at proper intervals of time, and be uniformly attended to by our ſurveyors. Since this recommendation, I have endeavoured to determine the variation at *Beverly*, with as much exactneſs as I was able. With this view, I procured an azimuth compaſs, of Dr. *Gowin Knight*'s invention. It appears to be good

good of its kind, and is furniſhed with a vernier, pointing out the azimuth to 5′; but the eye may pretty eaſily determine by it to 2′, and ſometimes to 1′. To obſerve by this compaſs, I aſcertained the going of my clock to great exactneſs, and on five different days, took ſeveral magnetical azimuths, both before and after the ſun paſſed the meridian, and noted the moments, which I have put down in apparent time. For theſe times, I have calculated the true azimuths by ſpheric trigonometry, and have carried out the variation for each obſervation ſeparately. On two days, I alſo determined the variation, by taking magnetic azimuths, at correſponding altitudes of the ſun, making proper allowances for the change of declination, between the obſervations of the forenoon and afternoon. On each of the days, ſome of the obſervations differ ſeveral minutes from others; but this I cannot attribute to want of attention, as I am conſcious that I made them with all the care in my power. The differences, I ſuſpect, principally aroſe from the difficulty of determining, with entire exactneſs, when the ſhadow from the hair was on the line beneath; and when in two obſervations, the error ſhould be on different ſides, the ſum might make a number of minutes. But I have the ſatisfaction of finding the mean reſults for the ſeveral days well agreeing with each other, which is a good evidence that the reſult of the whole muſt be, at leaſt, very near the truth.

Theſe obſervations and deductions are now humbly ſubmitted to the Academy, with wiſhes that they may ſubſerve the deſigned purpoſe.

JULY

JULY 27, 1781.

Ap. times of obs.	Sun's mag. az. per obs.	Sun's true az. per cal.	Varia. of the need.
11h 34′	S 8° 2′ E	S 15° 9′ E	7° 7 W.
11 36	7 0	14 2	7 2
11 50	S 1 10 W	5 57	7 7
11 58	5 55	1 15	7 10
12 4	9 28	S 2 26 W	7 2
12 20	18 45	11 45	7 0
12 26	22 15	15 10	7 5
12 28	23 30	16 17	7 13

Variation of the needle by a mean of 8 observations, July 27, 7 5¾

JULY 28.

11h 44	S 2° 25′ E	S 9° 19′ E	6° 54′ W.
12 4	S 9 15 W	S 2 20 W	6 55
12 6	10 35	3 30	7 5
12 8	11 45	4 40	7 5
12 22	19 45	12 46	6 59
12 26	22 5	15 2	7 3
12 30	24 15	17 16	6 59

Variation by the mean of 7 observations, of July 28. 7 0

JULY 30.

11 52	S 2 30 W	S 4 37 E	7 7 W.
12 2	8 15	S 1 10 W	7 5
12 6	10 28	3 28	7 0
12 18	17 28	10 19	7 9
12 26	21 55	14 47	7 8

Variation by the mean of 5 observations, of July 30, 7 5⅘

JULY 31.

11 29 32″	S 10 10 E	S 17 7 E	6 57 W.
11 39 32	4 35	11 37	7 2
11 43 32	2 20	9 23	7 3
11 51 32	S 2 5 W	4 51	6 56
11 55 32	4 32	2 34	7 6
11 59 32	6 40	0 16	6 56
12 1 32	7 50	0 53 W	6 57

Variation by the mean of 7 observations, of July 31, 6 59$\frac{4}{7}$

AUGUST 1.

11 53 52	S 3 32 W	S 3 28 E	7 0 W.
11 59 52	7 2	0 4	7 6
12 1 52	8 0	1 4 W	6 56
12 3 52	9 10	2 12	6 58
12 15 52	15 58	8 59	6 59

Variation by the mean of 5 observations, of August 1, 6 59⅘

Variation

Variations determined by magnetic azimuths, taken at equal altitudes of the sun, forenoon and afternoon.

AUGUST 6.

A. M.		P. M.		Difference.		½ Diff.=Variation.	
68°	28′	82°	30′	14°	2′	7°	1′ W.
65	30	79	20	13	50	6	55
63	50	77	35	13	45	6	52½
63	30	77	15	13	45	6	52½
63	0	77	0	14	0	7	0
62	30	76	32	14	2	7	1
Mean variation by the above six observations of August 6,						6	57
Equation for change of declination,							+ 4
Variation,						7	1

AUGUST 15.

67	30	81	30	14	0	7	0
67	10	81	5	13	55	6	57½
66	42	80	40	13	58	6	59
66	15	80	18	14	3	7	1½
66	2	79	55	13	53	6	56½
64	45	78	40	13	55	6	57½
64	12	78	8	13	56	6	58
63	58	77	48	13	50	6	55
63	37	77	35	13	58	6	59
63	0	77	6	14	6	7	3
61	46	75	45	13	59	6	59½
61	20	75	26	14	6	7	3
60	58	74	50	13	52	6	56
58	50	72	45	13	55	6	57½
58	30	72	25	13	55	6	57½
58	15	72	10	13	55	6	57½
57	40	71	30	13	50	6	55
57	10	70	58	13	48	6	54
56	43	70	42	13	59	6	59½
Mean variation by the above nineteen observations,						6	58¼
Equation for change of declination,							+ 5

Variation by nineteen observations of August		15,	7	3¼
Ditto	six	6,	7	1
Ditto	five	1,	6	59⅘
Ditto	seven	July 31,	6	59$\frac{4}{7}$
Ditto	five	30,	7	5⅘
Ditto	seven	28,	7	0
Ditto	eight	27,	7	5¾
Varian. by the mean of seven days, containing fifty-seven obs.			7	2

XII. *Magnetical Observations, made at* Cambridge. *By* STEPHEN SEWALL, *F. A. A.* Hancock *Professor of the Oriental Languages in the University.*

THESE observations were made at my house, with the accurate and elegant variation compass of *Nairne's* construction, belonging to the University, with which I was favoured by Professor *Williams*. The meridian-line, to which the instrument was applied, is presumed to be accurately true; no pains were spared to make it so.

Time.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
1782.	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″				° ′ ″
April 15								6 53									
16									6 56								
17								6 52									
18		6 44						6 52	6 47				6 45				
19		6 36						6 52									
20	6 37							6 54					6 45				
21																	
22	6 39																
23	6 43						6 59										
24		6 48					6 58					6 48					
25																	
26		6 49	6 41	6 51			6 55		7 3		6 52		6 54				
27																	
28																	
29			6 38	6 45	6 45	6 57	6 57	7 00*		6 55							
30		6 46	6 46			6 59	6 47	6 56			6 54		6 50				6 48‡
Mean.	6 39 40	6 44 36	6 41 40	6 48 00	6 45 00	6 58 00	6 55 12	6 54 09	6 55 20	6 55 00	6 53 00	6 48 00	6 48 30				6 48 00

6° 49′ 35″ Mean of the observations.

* Needle vibrating. ‡ Needle vibrating to 43′. Aurora Borealis.

Time.

Time.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
1782.	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
May 1				6 39		6 52			6 47	6 59		6 42					
2				6 40		6 43	6 48	6 51	6 54	6 49							
3	6 35		6 46			6 55	6 51			6 53							
4	6 41		6 41		6 54	6 50	6 58	7 08	6 54		6 53	6 46					
5																	
6	6 37		6 30		6 42		6 48										
7		6 50	6 39			6 55	6 55						6 37	6 48	6 58		
8	6 43	6 40	6 44					6 56								6 34	
9						6 56		6 53									
10	6 32					6 54	6 54		6 54				6 43			6 38‡	
11			6 39				6 50	6 50	6 55			6 52	6 40	6 48			
12									6 57				6 45	6 45		6 45	
13			6 40		6 51		6 56	6 52						6 42	6 42		
14	6 40	6 40	6 40	6 51	6 44	6 49	6 49	6 54	6 50	6 48	6 44	6 44		6 44	6 56	7 03	6 56
15		6 49	6 41	6 46	6 48	6 57	6 57	6 52	6 51			6 46	6 46	6 49		6 48	7 02
16		6 38	6 42	6 42		6 55	6 55	6 52			6 56		6 48	6 48		‖	
17		6 35	6 41				6 47	6 54				6 44	6 50			6 44	6 44
18	6 37	6 42	6 38			6 45	6 49	6 49						6 47	6 47	6 47	
19																	
20	6 30	6 37	6 33	6 36													
25		6 38	6 38	6 44		6 49	6 54	6 51	6 53		6 51			6 46		6 46	6 46
26							6 59	6 52				6 50	6 36			6 47	6 36
27	6 52*	6 44	6 42	6 54	6 56	6 49	6 51	6 55	6 47	6 51	6 51	6 47					
28			6 41	6 39												6 36	6 40§
29	6 42†	6 35	6 35	6 34		6 43	6 57	6 48		7 02	6 46	6 45					
30			6 35	6 39	6 43	6 47	6 53										
31													6 43				
Mean,	6 38 54	6 40 44	6 39 10	6 42 11	6 48 17	6 50 36	6 52 50	6 53 08	6 52 12	6 43 40	6 50 10	6 46 13	6 43 07	6 46 20	6 50 45	6 44 48	6 47 20

6° 46′ 30″ Mean of the observations.

* Needle vibrating. † Needle vibrating. ‡ Needle vibrating 10′. Small Aurora Borealis.
‖ Needle vibrating prevented an observation. § Small Aurora Borealis.

Time.

Time.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
1782,	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
June 1	6 39		6 45	6 47	6 43	6 46	6 54	6 52		6 55	6 49	6 45	6 45		6 40		
3			6 38		6 48	6 47	6 50	6 50	6 50	6 50	6 46	6 43					6 53
4				6 37	6 46	6 48	6 50	6 50	6 53	6 50		6 45†	6 44	6 44			
5			6 36		6 45	6 47	6 45	7 02	6 59	7 02	6 38	6 59	6 51	6 51			6 49§
6				6 37	6 43		6 45	6 50		6 52			6 46				6 48§
7				6 36		6 52	6 49	6 53	6 55				6 56‡	6 42	6 46	6 40	
8		6 41	6 46			6 48	6 49	6 49	6 49			6 41	6 44	6 38		6 51	
10			6 40		6 47	6 45	6 48	6 47	6 50	6 48				6 42	6 48	6 48	6 43
11	6 38		6 36	6 40	6 44	6 46	6 49	6 54			6 49		6 45	6 47			6 47
12	6 38	6 38	6 38	6 38	6 45	6 45	6 49	6 52	6 52	6 51	6 47*						
13	6 38		6 38	6 39	6 47	6 46	6 51	6 56	6 56	6 53	6 54	6 50		6 52		6 44§	
14			6 37			6 48	6 51	6 50					6 43‡				
15			6 33	6 43		6 47	6 49	7 01				6 50		6 46			
17			6 41	6 38		6 47	6 53		6 50		6 40		6 43				
18	6 37		6 38	6 38	6 38	6 44	6 46		6 48								
19	6 37		6 37	6 41		6 47		6 51	6 49								
28										6 49	6 56	6 43					
29			6 36			6 55	6 49					6 38		6 46			
Mean.	6 37 50	6 39 30	6 38 30	6 39 27	6 44 36	6 47 22	6 49 11	6 52 38	6 51 55	6 52 13	6 47 22	6 46 00	6 46 20	6 45 20	6 44 40	6 45 45	6 48 00.

6° 45′ 41″ Mean of all the observations.

* Thunder-storm. † Thunder in the west. ‡ Needle vibrating. § Small Aurora Borealis.

Time.

Time.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
July 1	° ′ ″	° ′ ″	6° 28′* ″	6° 35′ ″	6° 41′ ″	° ′ ″	6° 49′ ″	6° 51′ ″	6° 51′ ″	6° 51′ ″	6° 51′ ″	6° 51′ ″	6° 51′ ″	6° 44′ ″	° ′ ″	° ′ ″	° ′ ″
2			6 35	6 21	6 58†	6 40	6 49	6 54			6 46	6 50					
3	6 39	6 39	6 39	6 39	6 39	6 44	6 51	6 51	6 51	6 51	6 51	6 40					
4			6 32	6 48	6 41	6 47	6 48	6 48						6 40			
5			6 31			6 56	6 54						6 41	6 47			
6			6 36	6 36		6 55	6 47	6 47	6 56	6 52	6 41	6 41	6 41	6 41			
8			6 47	6 35													
10		6 28	6 37	6 42		6 48	6 55†	6 57†	6 44							6 34	
11	6 41	6 41	6 42	6 44	6 53	6 49	6 50	6 47	6 54								6 32
12			6 44	6 37	6 48	6 48	6 55	6 58	6 54	6 51				6 41		6 52†	6 52†
13			6 35	6 43	6 38	6 51	6 54	6 53	6 53	6 49							
15			6 34	6 47	6 41	6 47	6 50	6 54	6 48	6 49	6 43	6 41					
16		6 37	6 45	6 41	6 47	6 52	6 51	7 00	6 52	6 51	6 46	6 48	6 51	6 49			
17			6 38	6 44	6 49												
18					6 57	6 54	6 57	6 53	6 56				6 52			6 49	
19			6 38	6 41	6 43		6 51	7 00					6 53	6 50		6 50	6 47§
20						6 46	6 58										
22			6 39	6 42	6 53	6 50	6 50	6 56	6 53	6 51		6 48	6 56	6 56		6 47	
23			6 41	6 44	6 45	6 48	6 50	6 49	6 49	6 47		6 40	6 45			6 45	
24			6 29		6 45	6 52*	6 47*	6 58*	6 52		6 47	6 44		6 38	6 51	6 32	7 03‡
25			6 43	6 31	6 43	6 47	6 51	6 53	6 51		6 49	6 41	6 41	6 41	6 41	6 41	6 41
26				6 35	6 43	6 48	6 48	6 53	6 53	6 53		6 40	6 38	6 38		6 49	
27			6 34	6 38	6 41	6 49	6 54	6 54	6 52	6 46	6 42	6 44	6 44	6 44	6 44		
29			6 32	6 37	6 37	6 54	6 50	6 50	6 50					6 47		6 44	
30		6 33	6 38	6 42	6 45	6 45	6 48	6 48	6 48	6 51	6 45	6 45	6 45				
31			6 33	6 38	6 57	6 58	6 50	6 55	6 48	6 49			6 39	6 39			
Mean.	6 40 00	6 35 36	6 36 57	6 39 05	6 115 54	6 49 27	6 51 07	6 53 08	6 51 19	6 50 05	6 46 06	6 44 05	6 45 55	6 43 56	6 45 20	6 44 18	6 47 00

6° 45′ 15″ Mean of all the observations.

* Thunder-storm. † Needle vibrating. § Vibrating to 7° 03′. Aurora Borealis. ‡ 10¾h. 6° 34′.

Time.

Time.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
1782.	° ′ ″		° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	
Aug. 1			6 39	6 39	6 39	6 41	6 44	6 48	6 46	6 48	6 42				6 48	6 40	
2			6 34	6 42	6 42	6 49	6 47	6 51	6 51	6 50	6 45	6 41					
3			6 41	6 41	6 47	6 47	6 49	6 49	6 51	6 51		6 47	6 44		6 40		
5			6 31	6 39	6 39	6 43	6 50	6 52	6 48	6 52	6 47						
6			6 37		6 45	6 50	6 53	7 01	6 49	6 47	6 46			6 46			
7	6 41		6 38	6 37		6 51	6 58	6 55	6 41		6 49	6 46		6 41			
8			6 36	6 42	6 42	6 46	6 55		6 54	6 48	6 52	6 47					
9			6 28*	6 47*	6 45*	6 55	6 50		6 53	6 51				6 45			
10			6 32	6 36	6 42	6 45	6 48		6 51		6 45		6 43				
12			6 35		6 40	6 42	6 47		6 53	6 48				6 38			
13			6 35		6 47	6 47	6 52	6 52	6 54	6 50	6 46					6 40	
14			6 31	6 41	6 41	6 52	6 45	6 52			6 49		6 49	6 49	6 49	6 49	
15			6 34		6 47												
17			6 37		6 44	6 47		6 46									
19			6 31	6 40	6 36	6 47	6 51	6 55	6 51	6 47	6 41	6 43	6 43				
20			6 38	6 38	6 46		6 54	6 48	6 53	6 43	6 43	6 43	6 43	6 43	6 43	6 35	
Mean,	6 41 00		6 35 26	6 40 11	6 42 48	6 47 17	6 50 09	6 51 44	6 50 23	6 48 38	6 45 55	6 44 30	6 44 24	6 43 40	6 45 00	6 41 00	

6° 44′ 48″ Mean of all the observations.

The mean of all the observations, from May to August, makes the variation 6° 46′ 22″ W.

* Needle vibrating.

XIII. *An Historical Register of the Aurora Borealis, from August the 8th, 1781, to August 19, 1783.* By CALEB GANNETT, *A. M. Rec. Sec. A. A.*

Aug. 8, 1781. AN Aurora Borealis appeared in a common form, from eight o'clock till after ten. A luminous arc extended horizontally from north-west to north-east. The height of the arc, about 25°. A thick dusky vapour lay below. A few small strice ascended from the body of light. At 10h. 15', a column of light ascended from about north-north-west,—passed north of *Arcturus*, and crossing the meridian in the zenith, extended to the east, to about 30° of the horizon. Thus it remained for several minutes, and then moved slowly southward, till 10h. 45', when it vanished.

Meteors appeared in great numbers, shooting, in general, from north-west to south-east.

22. An Aurora Borealis,—of little extent, and faint.

23. ditto, ditto.

Sept. 18. ditto, ditto.

19. Appeared an auroral segment, extending from north-north-west, nearly east, supported by a dark vapour. A second luminous segment soon appeared above the first,—a thick dusky vapour intervening between the two. Some strice proceeded from the uppermost segment, which appeared to curve directly towards the zenith. About ten o'clock, a column of light shot up from the east, and crossing the meridian north of the zenith, passed some degrees west of the meridian. At eleven o'clock, appeared a number of corruscations; after which, the whole declined, till an entire disappearance.

Sept.

Sept. 25. At $7^{h.}$ 30′, an auroral arc appeared. Its meridional height about 53°. At $7^{h.}$ 45′, ſtriæ proceeded from the arc towards the zenith—their colour, in general, white.——Thoſe ſtriæ, from being regular, ſoon appeared like broken ſheets of light. At $8^{h.}$ 10′, the various interrupted ſtriæ, riſing from weſt-ſouth-weſt to eaſt-ſouth-eaſt, concentered at about 10° ſouth of the zenith. Glades, diverging from that point, extended to 15° in length, in every direction. After remaining in this ſtate about ſeven minutes, the northward radii recoiled towards the centre. The whole phenomenon, from that time, decreaſed rapidly. At $8^{h.}$ 20′, nothing more than a common Aurora was viſible. The ſtriæ from weſt-north-weſt were very red, and attended with corruſcations. At $8^{h.}$ 26′, the height of the luminous arc not more than 40°. Two or three ſmall ſtriæ; alſo, very thin white corruſcations obſervable, whoſe horizontal extent was from weſt to north, and vertical to 10° ſouth of the zenith. At $8^{h.}$ 30′, corruſcations ceaſed, and the light in the north ſcarcely ſo much as to attract notice. At $8^{h.}$ 37′, the light increaſed.—Striæ began to aſcend from the eaſt, very red.—The general arc appeared to generate new arcs, which travelled ſouthward, till the uttermoſt reached the zenith at $8^{h.}$ 43′. Between the arcs, which were not quite regular, proper ſky appeared,—in ſome parts, 5° in width, in others 3°. At $8^{h.}$ 46′, regular ſtriæ aſcended from north-weſt to eaſt, to 5° ſouth of the zenith, and terminated in a ſegment of a circle, whoſe diameter was about 9°. A quantity of the vapour, in appearance like a ſmall, thin, white, irregular cloud, collected at about 6° ſouth of the fore-mentioned ſegment. At $8^{h.}$ 54′, the ſtriæ continued;—the ſegment, in which they terminate, enlarged.—From nine o'clock, a gradual decreaſe, till the whole diſappeared.

Oct.

Oct. 15. At $8^{h.}$ 16′, a luminous arc commenced in a point within two or three degrees of the horizon, nearly east.—— Thence diverging, it passed about 8° south of *Pleiades*, and proceeding between the stars in *Andromeda's Shoulder* and those in his left arm, crossed the meridian at about 13° south of the zenith, and extended to about 20° west of the meridian. At 5° altitude, the light was vivid and strong. From that height the light became more faint, till it became imperceptible at the afore-mentioned distance west of the meridian. The whole advanced south slowly, and disappeared at $8^{h.}$ 33′, Auroral light was visible also from north-west to north.

19. A small Aurora.

Nov. 13. Ditto.

14. Ditto.

15. Ditto.

19. An Aurora extended from north-west to north-east.—White, except a red spot in the north-east :—and in the north-west, red and yellow. Striæ,—numerous, but not long.

March 9, 1782. A small Aurora.

April 2. Ditto.

4. Ditto.

14. Ditto.

May 9. Ditto.

22. From an extensive Auroral arc, striæ proceeded, till they almost reached the zenith. Their motion, at first, regular, afterwards, flashing and quivering.

July 9. A small Aurora.

10. Ditto.

Aug. 26. An Aurora. Striæ,—white but not long.

Sept. 13. An Aurora continued through the night. Its horizontal extent, from west-south-west to north-east. Its complexion, white and vivid. Some striæ, though not numerous. In the west, the dusky vapour, near the horizon, appeared in two segments of a circle; one extending southward, the other northward.

14. An Aurora afforded a few striæ. One striæ, generated from the southern limit of the horizontal light, ascended almost to the zenith. It diverged very much in its ascent. After continuing at its greatest height for a minute or two, it subsided to about 50° altitude. At 10h. 30′, the lower part, at about 15° altitude, became detached from the light below, and in the form of a narrow glade, remained suspended for several minutes, and then vanished.

22. At ten o'clock, a yellow stria of Auroral light appeared single in the west-south-west, without any dusky vapour beneath it; but rising from about 20° above the horizon, out of a smoky haze, and ascending to 55° altitude. It continued bright a few minutes, and then became faint. Three small striæ, at a small distance west of the former. After a continuance of about a quarter of an hour, the whole disappeared.

29. A small Aurora.

30. An Aurora—Inconsiderable through the evening. At twelve o'clock, striæ were numerous, frequent, and their motion brisk and undulatory.

Oct. 2. A small Aurora.

9. Ditto.

10. Ditto.

26. Ditto.

Jan. 26, 1783. Ditto.

Feb.

Feb. 2. A ſmall Aurora.
21. Ditto.
27. Ditto. A few white ſtriæ.
March 2. Ditto.
9. Ditto.
27. Ditto.

29. An Aurora was viſible at the horizon, extending from north-weſt to nearly north-eaſt. The whole arc, included within thoſe limits to about 12° altitude, quite luminous. At $7^{h.} 20'$, the uſual duſky appearance commenced at the horizon, and increaſed till it became about 15° altitude. Light proceeded from the upper part, not as from the periphery of a regular arc, but from different heights. Striæ, frequent and diſconnected, often appearing like rare white luminous clouds, varying their poſition and continually riſing, till $7^{h.} 50'$ they reached the zenith. Striæ more prevalent, paſſing the zenith. At $8^{h.}$, appeared a detached bright Auroral cloud in the ſouth-eaſt, within about 30° of the horizon.—Another long ſimilar cloud in the ſouth-weſt, paſſing ſwiftly downward to the ſame diſtance from the horizon;—thence, with a quick motion, weſtward;—then vibrated from eaſt to weſt in an arc of ſeveral degrees. Each Auroral cloud frequently diſappeared in an inſtant, then revived with equal, or ſuperior, luſtre.—Thus they continued a few minutes, and then entirely vaniſhed. The ſtriæ, which were hitherto frequent and briſk, tho' irregular, appeared to collect at about 5° ſouth of the zenith, and there formed a large body of light.—Soon ſucceeded new ſhootings of ſtriæ,—ſtrong and regular; and below them, a frequent flaſhing of light. Between the ſtriæ and luminous glades was the ſame duſky appearance, as in the cloud near the horizon. At $8^{h.} 15'$, a corona formed at about 3° ſouth

ſouth of the zenith, ſurrounding a ſmall unilluminated circle. Dilated ſtriæ proceeded from it in every direction. The corona ſoon changed its form, and became two ſegments of a circle, convex towards the centre of the corona. Radii proceeded nearly north and ſouth, diverging. Theſe preſently ceaſed. At $8^{h.}\ 25'$, faint glades of light remained near the zenith, entirely detached from a large body of light extending from weſt-north-weſt to nearly eaſt.—Theſe in a tremulous motion, and frequently ſhooting very nimbly with increaſed luſtre. At $8^{h.}\ 40'$, light ſhooting briſkly from eaſt-north-eaſt in their glades, a little ſouth of the zenith, to about $18°$ weſt. Several apparently compact ſpots of light near the zenith, below which, corruſcations were very briſk. Calm till $8^{h.}\ 45'$.—Wind then freſh from weſt. At $9^{h.}\ 30'$, the Aurora, for three quarters of an hour paſt, having been upon the decline, ſettling down into a general body of light of a dull appearance, without a very duſky cloud near the horizon,—now re-commenced in vivid ſtriæ from the top of a black arc, about $25°$ altitude. At $9^{h.}\ 35'$, the ſtriæ, from ſhooting very nimbly, became corruſcations,—paſſed conſiderably ſouth of the zenith, and continued ſeveral minutes in very quick vibrations. At $9^{h.}\ 50'$, no uniform duſky appearance near the horizon,—the light appearing in detached clouds from thence upwards, dancing and flaſhing to the zenith. At $10^{h.}\ 15'$, ſubſided into a general body of light.

March 30. A ſmall Aurora.

April 3. Appeared a number of Auroral ſpots. After a ſhort continuance, they vaniſhed. No other Auroral light viſible.

7. In the beginning of the evening, appeared a common white Aurora, forming an agreeable arc at about $20°$ altitude, extending

extending from north-weſt to north-eaſt, ſupported by a thick duſky cloud, as uſual; through which ſeveral ſtars were plainly viſible, eſpecially one very near the horizon. At eight o'clock, ſtriæ began to ſhoot. From $8^{h.}\ 15'$ to $8^{h.}\ 30'$, the light ſhot into different forms, detached in large ſpots or clouds. At $8^{h.}\ 30'$, a column of light aroſe from weſt-north-weſt; and, paſſing about 15° north of *Procyon*, extended ſeveral degrees eaſt of the meridian. At the ſame time, another column aſcended from nearly eaſt, at a conſiderable diſtance from the horizon,—paſſing a few degrees ſouth of the other, and terminating a little weſt of the meridian. Thoſe parts of the heavens included between the Auroral clouds, had a ſimilar appearance with the duſky cloud, which uſually appears beneath an Auroral arc. Stars were very viſible in thoſe included parts. The two columns from eaſt and weſt, moved ſlowly ſouth a few minutes, and then diſappeared. Afterwards, the light decreaſed till nine o'clock, when it became an ordinary Aurora.

April 11. A ſmall Aurora.

27. Ditto.

May 13. An Aurora commenced in the beginning of the evening;—aſcended in ſtriæ;—afterwards changed into whitiſh clouds, very thin, and in detachments paſſed the zenith,—travelled ſouthward, and continued viſible within 20° of the horizon. It ſoon declined, and in a little time was reduced to a common Aurora.

29. A ſmall Aurora.

Aug. 1. Ditto.

16. Ditto.

19. Ditto.

XIV. *A comparative View of Thermometrical and Barometrical Observations, at* Cambridge. *By the Rev.* EDWARD WIGGLESWORTH, *S. T. P.* Hollis, *F. A. A.*

A comparative View of Thermometrical Observations.

	1780.				1781.				1782.				1783.			
	High.	Low.	Range.	Mean.	High.	Low.	Range.	Mean.	High.	Low.	Range.	Mean.	High.	Low.	Range.	Mean.
January,					$48\frac{1}{2}$	13	$35\frac{1}{2}$	32	46	2	44	25	44	0	44	27
February,					45	9	36	31	41	1	40	27	55	$0:1\frac{1}{2}$	$56\frac{1}{2}$	34
March,					$50\frac{1}{2}$	25	$25\frac{1}{2}$	37					59	13	46	36
April,					59	35	24	45					77	35	42	52
May,					77	41	36	58					77	46	31	59
June,	77	51	26		78	50	28	65					85	54	31	72
July,	89	66	23	75	86	65	21	74					91	62	29	72
August,	92	62	30	76	$85\frac{1}{4}$	63	$22\frac{1}{4}$	72	84	$58\frac{1}{2}$	$25\frac{1}{2}$	72	$88\frac{1}{2}$	$56\frac{1}{2}$	32	70
September,	78	49	29	64	81	57	24	67	$85\frac{1}{4}$	$49\frac{1}{2}$	$35\frac{3}{4}$	65	72	45	27	60
October,	68	39	29	51					66	$39\frac{1}{2}$	$26\frac{1}{2}$	51	62	38	24	50
November,	57	25	32	38	54	21	33	36	52	20	32	38	53	19	34	36
December,	55	12	43	31	41	15	26	30	56	12	40	33	61	12	49	32

A comparative View of Barometrical Obſervations.

	1780.				1781.				1782.				1783.			
	Higheſt.	Loweſt.	Range.	Mean.	Higheſt.	Loweſt.	Range.	Mean.	Higheſt.	Loweſt.	Range.	Mean.	Higheſt.	Loweſt.	Range.	Mean.
January,					30 30	28 83	1 47	29 66	30 57	29 40	1 17	30 05	30 33	29 04	1 29	29 64
Feb.					30 16	29 06	1 10	29 66	30 55	29 39	1 16	29 97	30 34	29 20	1 14	29 85
March,					30 26	29 16	1 10	29 76					30 12	28 91	1 21	29 71
April,					30 18	28 96	1 22	29 64					30 30	29 40	0 90	29 86
May,					30 05	29 41	0 64	29 75					30 32	29 42	0 90	29 86
June,	30 09	29 19	0 90		30 03	29 32	0 71	29 76					30 27	29 52	0 75	29 86
July,	30 20	29 50	0 70		30 19	29 71	0 48	29 98					30 18	29 47	0 71	29 87
Auguſt,	30 13	29 61	0 52	29 90	30 27	29 66	0 61	30 00					30 20	29 49	0 71	29 87
Sept.	30 15	29 38	0 77	29 82	30 40	29 67	0 73	30 02	30 24	29 69	0 55	29 97	30 23	29 42	0 81	29 82
October,	30 25	29 64	0 61	29 98					30 24	29 42	0 82	29 82	30 29	28 98	1 31	29 74
Nov.	30 41	28 90	1 51	29 73	30 50	29 15	1 35	29 76	30 50	29 20	1 30	29 80	30 39	28 72	1 67	29 70
Dec.	30 27	28 83	1 44	29 75	30 37	29 00	1 37	29 75	30 30	29 04	1 26	29 76	30 25	28 68	1 57	29 68

XV. *Meteorological Observations at* Ipswich, *in* 1781, 1782 *and* 1783. *Lat.* 42°38′30″N. *Long.* 70°45′ W. *By the Reverend* MANASSEH CUTLER, *F. A. A. and M. S. and Member of the Philosophical Society at* Philadelphia.

THE thermometer used in the following observations, was made by *Gilbert*, on *Farenheit's* scale, with a tube fourteen inches in length. It is placed in an entry-way, remote from fire or the rays of the sun. The barometer is of the portable kind, made by *Hair*. The quantity of rain is measured by an ombrometer, made of tin, twelve inches square at the mouth, the sides of which are perpendicular. The rain falls through the mouth into a funnel, which conducts it into a reservoir, where it is secured from evaporation; and is, afterwards, decanted off and measured in a three-inch cubic measure. It stands firmly secured, in an open situation, with the mouth about two feet from the ground. The quantity of water contained in snows, is generally ascertained by taking the cubic measure of a column of snow, at its mean depth, from the surface to the bottom, and dissolving it in the ombrometer. But as snows frequently fall one upon another, or are accompanied with rain, there is great difficulty in ascertaining, with exactness, the quantity of water that falls during the winter.

In the account of diseases, not every disorder that occured, but only such as were most prevalent, are inserted. *Edward A. Holyoke*, M. D. favoured me with the account of diseases in *Salem*; Dr. *Isaac Spafford* with those in *Beverly*, and Dr. *Elisha Whitney* with those in *Ipswich*.

Days.

Days.	H.	Ther.	Wind.	Weather.
1	8	31	NW. SW.	Fair.
	1	38		
	10	40		
2	8	39	SW.	Fair.
	1	44		
	10	43		
3	8	37	N.	Cloudy and ſnow.
	1	36		
	10	33		
4	8	31	SW.	Clouds & ⊙ſhine.
	1	35		
	10	36		
5	8	39	SW. W.	Fair, pleaſant.
	1	49		
	10	42		
6	8	37	W. SW.	Fair, fine day.
	1	41		
	10	42		
7	8	40	SW. N.	Clouds and rain.
	1	41		
	9	36		
8	8	23	NW.	Fair.
	1	24		
	10	23		
9	8	18	NW.	Cloudy, ſnowed a little.
	1	23		
	10	26		
10	8	33	N. SE.	A little ſnow, then rainy and foggy.
	1	40		
	10	41		
11	8	39	W.	Fair, high wind.
	1	44		
	10	43		
12	8	40	W.	Fair.
	1	44		
	10	40		
13	8	36	NW.	Fair.
	1	37		
	10	35		
14	8	31	SE.	Snow P. M. & moſt of the night.
	1	35		
	9	37		
15	8	35	W.	Fair. About 5 inches of ſnow on the ground.
	1	38		
	10	33		
16	8	26	W. NW.	Clouds & ⊙ſhine.
	1	31		
	10	27		
17	8	21	NW.	Clouds & ⊙ſhine. In the evening Aurora Borealis.
	1	23		
	10	28		
18	8	21	NW.	Fair.
	1	27		
	10	28		
19	8	27	NW.	Fair.
	1	35		
	10	34		
20	8	27	N.	Cloudy.
	2	36		
	10	37		
21	8	36	NE.	Snow; rain; foggy.
	2	39		
	10	39		
22	8	36	NW.	⊙ſhine ; clouds ; ſnow.
	1	38		
	10	37		
23	8	31	NE. NW.	Snowed ; wind very high.
	2	37		
	10	30		
24	8	29	WSW. W.	Clouds and ſnow. About 6 inches of ſnow on the ground.
	2	34		
	10	33		
25	8	31	NW.	Fair. Faint Aurora Borealis at night.
	1	35		
	10	31		
26	8	26	NW.	Fair, pleaſant.
	1	31		
	10	32		
27	8	27	N.	Cloudy ; at night rain.
	2	32		
	9	36		
28	8	40	SW. W.	Fair, fine day.
	2	42		
	10	37		
29	8	32	SW.	Fair.
	1	37		
	10	37		
30	8	32	SW. NW.	Rain ; fair ; high wind. Faint Aurora Borealis.
	1	39		
	10	35		
31	8	28	NW.	Fair. A very faint Aurora Borealis.
	1	31		
	10	31		

Therm.	A. M.	Noon.	P. M.
Higheſt,	40°	49°	43°
Loweſt,	18	23	23
Mean ſtat.	32	36	33

The month, in general, open and mild. The frequent ſmall ſnows that fell, ſoon melted. Some days as pleaſant as April.

Diſeaſes in *Ipſwich* ; worm caſes, ſome fevers, frequent abſceſſes, cephalalgias, ophthalmias—Healthy.

Diſeaſes in *Salem* ; ophthalmias, a few pleuriſies and peripneumonys, a few vomitings and purgings, and worm caſes.

Diſeaſes in *Beverly* ; pleuritic and peripneumonic fevers, worm caſes, vomitings and purgings.

Days.	H.	Ther.	Wind.	Weather.	Days.	H.	Ther.	Wind.	Weather.
1	8 1 10	28 33 36	SW. S.	Cloudy, a little ſnow.	15	8 1 10	39 41 43	W. NW.	Fair. At night Aurora Borealis.
2	8 1 10	38 40 41	SSW. Calm.	Rain, foggy.	16	8 1 10	41 38 37	S. SE.	Clouds; ſnow; ☉ſhine.
3	8 1 10	41 45 37	WNW. W.	Fair, a very fine day.	17	8 1 10	37 40 34	W. NW.	Thunder & lightning in the morn. clouds and ☉ſhine P. M.
4	8 1 10	27 31 30	NE.	Mild ſn. ſtorm; ſnow fell 6 inches deep.	18	8 1 10	26 28 29	NW.	Fair, very cold.
5	8 1 10	27 35 34	W.	Fair A. M. Rain in the evening.	19	8 1 10	27 34 37	S.	Snow and rain.
6	8 1 10	31 35 32	NW.	Fair.	20	7 1 10	34 32 27	NW.	Fair.
7	8 1 10	28 32 33	SW.	Very clear.	21	7 1 10	23 31 32	W.	Fair.
8	8 1 10	30 35 36	SW.	☉ſhine and clouds.	22	8 1 11	34 38 37	E. NW.	Snow & rain; ſnow fell about 6 inches deep.
9	8 1 10	23 20 21	NW. SW.	Very cold wind. Ther. rem. out of doors, the mercury ſtood at 0, at ¼ after 9 o'clock, A. M.	23	8 1 11	35 37 38	NE.	Hail and rain.
10	8 1 10	19 22 20	NE.	Severe ſnow ſtorm; high winds; ſno. much drifted, about 16 inches deep.	24	7 1 11	36 40 39	SW. W.	Fair.
11	8 1 10	27 24 23	NW.	Fine fair day.	25	7 1 10	36 40 39	SW. W.	Fair.
12	8 1 10	14 23 21	NW.	Fair.	26	7 2 10	32 34 33	W. NW.	Fair.
13	8 1 10	19 28 32	W. SW.	Fair.	27	7 1 10	30 36 39	W. SW.	Cloudy.
14	8 1 10	35 42 41	SW.	Fair.	28	8 1 10	40 44 38	NW.	Fair.

Thermometer.		A. M.	Noon.	P. M.
	Higheſt,	41°	45°	43°
	Loweſt,	14	20	20
	Mean ſtat.	30	34	33

The ground covered with ſnow during the month.

Diſeaſes in *Ipſwich*; ſome remittent and bilious fevers, pulmonary phithiſes—Very healthy.
Diſeaſes in *Salem*; ophthalmias, chicken pox, abſceſſes, a few anginas, pleuriſies, hæmæptoes.
Diſeaſes in *Beverly*; ſlow remittent fevers, abſceſſes, rhumatiſms.

Days.

Days.	H.	Ther.	Wind.	Weather.
1	7	31	N. SW.	⊙ ſhine ; clouds ; rain.
	1	32		
	10	35		
2	7	34	E.	Clouds ; rain and hail.
	2	37		
	10	38		
3	7	38	SW. W.	Fair ; wind high.
	1	40		
	11	38		
4	7	34	NW.	Fair.
	1	38		
	10	35		
5	8	31	SW.	Cloudy, ſnow.
	2	38		
	10	37		
6	7	39	SW.	⊙ ſhine and clouds.
	1	45		
	11	43		
7	8	35	NE.	A N.E. ſn.ſtor. wind very high ; ſnow fell 4 inches deep.
	1	32		
	10	29		
8	7	30	NW.	Snow A. M. ⊙ ſhine and clouds.
	1	32		
	11	32		
9	7	27	NW. W.	Fair.
	1	36		
	10	34		
10	7	31	NW. W.	Fair.
	1	39		
	10	38		
11	7	34	NW.	Fair.
	1	42		
	10	43		
12	7	39	W. SW.	Fair.
	1	46		
	11	42		
13	7	37	NW.	Fair.
	2	41		
	10	37		
14	7	31	SE.	Snow and rain.
	1	37		
	11	39		
15	7	40	SW. NE.	⊙ ſhine ; rain , foggy.
	1	50		
	11	47		
16	7	46	NW.	Fair.
	1	47		
	11	42		

Days.	H.	Ther.	Wind.	Weather.
17	7	39	SW.	Fair.
	2	47		
	10	42		
18	7	43	NE.	Clouds ; rain ; ⊙ ſhine.
	2	45		
	10	43		
19	8	40	E. SW.	Rain ; wind high ; ⊙ ſhine.
	2	43		
	10	41		
20	7	40	NW.	Fair ; high wind.
	2	48		
	10	36		
21	7	37	NW.	Fair ; wind high.
	2	41		
	10	40		
22	7	36	NW.	Fair.
	2	40		
	9	38		
23	7	35	S. E.	Rain ; ſnow ; miſty.
	2	37		
	11	42		
24	7	43	W. N.	Fair.
	2	50		
	9	44		
25	7	36	NW.	Fair.
	2	38		
	9	36		
26	8	35	NW. SW.	Rain ; ſnow at night, fell 2 inches deep.
	2	41		
	9	39		
27	7	36	NW.	Fair. Aur. Bor. at night ; a bri. glade of light from S.E. to N.W. acroſs hemiſ.
	2	39		
	9	37		
28	7	30	SE. N.	Snow & rain ; wind exceſſive high.
	1	32		
	9	33		
29	7	32	N.	Squally, ⊙ ſhine. At night a faint Aurora Borealis.
	1	35		
	10	34		
30	7	31	NW.	Fair.
	1	30		
	11	41		
31	7	36	NW.	Fair.
	2	43		
	10	41		

Them.		A. M.	Noon.	P. M.
	Higheſt,	46°	50°	47°
	Loweſt,	27	32	29
	Mean ſta.	36	40	38

The weather frequently coldy and bluſtering, but no very violent ſtorms. Froſt nearly out of the ground at the cloſe of the month.

Diſeaſes in *Ipſwich* ; bilious and peripneumonic fevers, palſies, worm caſes.
Diſeaſes in *Salem* ; anginas, pleuriſies, cholics, worms.
Diſeaſes in *Beverly* ; mixed fevers, chronic rhumatiſms, worms, anginas.

Days.	H.	Ther.	Wind.	Weather.	Days.	H.	Ther.	Wind.	Weather.
1	6	37	NW. N.	Fair.	16	7	42	NE.	Fair.
	2	45				2	49		
	9	45				10	44		
2	7	38	NE.	Violent ſtorms of rain, ſnow & hail; high wind.	17	7	41	NE. SW.	⊙ ſhine and clouds.
	2	40				2	46		
	11	39				9	45		
3	7	38	N. NE.	Very high wind; ſome ſnow & rain.	18	7	46	NW.	Fair.
	2	40				2	50		
	9	40				9	47		
4	7	37	NW. W.	Fair.	19	7	45	SE. NE.	Rain.
	2	43				1	47		
	10	40				9	44		
5	7	41	W.	Fair.	20	7	42	NE.	Small rain.
	2	52				2	43		
	10	50				9	42		
6	6	45	N. NE.	Fair.	21	7	45	N. NE.	⊙ ſhine and clouds.
	1	50				2	49		
	10	48				9	47		
7	7	45	NE.	Fair.	22	7	45	N. SE.	⊙ ſhine and clouds; very high wind.
	2	49				1	49		
	10	46				10	47		
8	7	49	NE. SW.	Small rain.	23	7	44	W. SW.	⊙ ſhine and clouds.
	2	48				2	49		
	10	46				10	46		
9	7	41	WNW	Fair; exceſſive high wind.	24	7	43	SSE.	Rainy.
	1	43				2	49		
	10	42				9	46		
10	8	41	SE. S.	Fair.	25	7	48	W.	Clouds and ⊙ ſhine.
	2	50				1	51		
	10	46				10	55		
11	7	42	NE.	Very rainy.	26	6	55	W.	Clouds and ⊙ ſhine.
	2	43				2	57		
	10	42				9	56		
12	7	42	W. SW.	Fair.	27	6	52	N.	Fair.
	2	49				1	54		
	11	45				9	47		
13	7	43	NW.	Cloudy.	28	6	45	N. SW.	Fair.
	2	45				1	58		
	10	43				10	51		
14	8	39	NW.	Fair.	29	6	48	SW.	Fair.
	2	45				2	56		
	10	42				11	54		
15	6	38	NW.	Fair.	30	6	51	S.	Cloudy; foggy; rain.
	1	46				2	52		
	9	48				11	56		

Therm.		A.M.	Noon.	P.M.
	Higheſt,	55°	58°	56°
	Loweſt,	37	40	39
	Mean ſtat.	44	48	46

Very bluſtering and cold the greater part of the month. Vegetation very backward.

Diſeaſes in *Ipſwich*; pleuritic and peripneumonic fevers, bilious diſorders—Healthy in general.

Diſeaſes in *Salem*; pleuriſies, peripneumonics, coughs and colds, anginas, pulmonary phthiſes, hæmæptoes, worms, a few mild, putrid, ulcerated throats—Sickly for the ſeaſon.

Diſeaſes in *Beverly*; pleuriſies, peripneumonics, coughs, colds, anginas and hæmæptoes.

Days.

Days.	H.	Ther.	Barom.	Wind.	Weather.	Days.	H.	Ther.	Barom.	Wind.	Weather.
1	6	54		W.	Fair.	17	6	58	29,83	NW. E.	Rain, thunder and lightning.
	1	60					1	59	90		
	9	65					9	58	87		
2	7	50		SW.	⊙ſhine & clouds.	18	6	56	90	NE.	⊙ſhine and clouds.
	1	62					1	62	91		
	9	60					10	57	93		
3	6	57		NW. W.	Fair.	19	6	54	30,0	SW.	Fair.
	2	60					2	65	29,86		
	10	58					9	62	86		
4	7	50		NW. W.	Fair. Violent whirlwind from NW. to SE.	20	6	58	89	W.	⊙ſhine; ſmall rain.
	1	55					1	67	54		
	11	51					10	69	46		
5	7	52		SW. E.	Fair.	21	7	65	55	NW. NE.	Clouds and ⊙ſhine.
	1	58					2	61	60		
	10	57					10	66	66		
6	6	53		S.	Fair; wind high.	22	7	59	92	NE. SW.	Clouds and ⊙ſhine.
	2	62					2	60			
	9	58					10	56	30,21		
7	6	55		ESE.	Clouds & ⊙ſhine; high wind.	23	6	56	20	E. SE.	⊙ſhine and clouds.
	2	58					1	62	16		
	10	50					9	57	20		
8	7	47		NE.	Very rainy.	24	6	55	20	NE.	⊙ſhine and clouds.
	2	48					1	61	15		
	11	47					10	53	10		
9	6	45		N.	Exceſſive rain—a very great quantity fell in 48 hours.	25	6	52	03	NE.	Very rainy.
	1	44					1	52	29,96		
	10	43					10	52	90		
10	6	43		NE.	⊙ſhine and clouds.	26	6	51	90	W.	Pleaſant, fair.
	1	44					1	58	89		
	9	45					10	57	88		
11	6	42		NE.	Fair.	27	6	57	91	SW.	Fair, a very fine day.
	1	54					1	66	86		
	9	52					10	65	90		
12	8	49		NE.	Clouds, ſmall rain.	28	6	61	99	WSW.	Fair.
	1	50					1	77	65		
	9	52					10	71	80		
13	6	49	29,96	NW.	Clouds and ⊙ſhine.	29	6	67	85	SW.	Clouds and ⊙ſhine.
	1	54	97				1	81	55		
	9	52	98				10	71	65		
14	6	48	30,08	NW. SW.	Fair.	30	6	68	85	SW.	⊙ſhine and clouds.
	2	63	29,98				1	74	67		
	11	58	82				10	68	80		
15	6	58	77	W.	Fair.	31	7	65	95	W.	Fair.
	1	67	51				1	65	30,05		
	10	67	50				10	63			
16	6	60	71	SW. E.	Clouds and ⊙ſhine.						
	1	63	69								
	10	62	76								

Therm.		A. M.	Noon.	P. M.
	Higheſt,	68°	77°	71°
	Loweſt,	42	44	43
	Mean ſtat.	55	57	58

The month, in general, cold and wet. Vegetation very backward—graſs ſhort and thin—Indian corn planted much later than uſual.

Diſeaſes in *Ipſwich*; continued and remittent fevers, peripneumonies, rheumatiſms, palſies, worm caſes.
Diſeaſes in *Salem*; convulſions, vomitings and purgings, worms, pleuriſies, rheumatiſms, ſeveral mild dyſenteries, abſceſſes, coughs and hæmoptoes.
Diſeaſes in *Beverly*; pleuriſies, convulſions, worms, rheumatiſms.

Days.

Days.	H.	Ther.	Barom.	Wind.	Weather.
1	7	61	30,01	E.	Fair.
	1	64	05		
	10	61	09		
2	6	61	05	N.	⊙ fhine and clouds.
	1	61	03		
	10	67	01		
3	6	58	05	NW. E.	Fair.
	2	67	29,96		
	9	62	30		
4	6	57	12	N. E.	Fair.
	2	63	06		
	10	59	18		
5	6	55	22	SSE. S.	Fair.
	2	64			
	10	63			
6	6	59		NE.	Cloudy ; foggy.
	2	67	01		
	9	64	29,99		
7	7	60	90	ENE. NE.	Cold N.E. ftorm, very rainy.
	1	58	62		
	9	54	69		
8	6	51	60	NE.	Rainy.
	2	53	65		
	10	53	63		
9	6	53	61	W.	Mifty.
	1	61	55		
	10	62	58		
10	7	60	63	WNW	⊙ fhine, clouds, thunder.
	1	69	54		
	9	65	64		
11	6	63	79	NW.	Fair.
	2	72	65		
	10	60	71		
12	6	63	81	SW.	Fair.
	1	75	59		
	9	73	53		
13	6	68	58	SW.	⊙ fhine and clouds.
	2	76	30		
	9	73			
14	6	69	50	SW.	⊙ fhine and clouds ; very fultry.
	1	77	49		
	10	73	44		
15	6	70	51	N.	Small rain.
	2	67	51		
	10	66	56		
16	6	61	29,73	NW.	Fair.
	2	68	69		
	10	64	77		
17	7	65	79	W. SW.	⊙ fhine ; clouds ; fmall rain.
	1	69	66		
	10	67	72		
18	6	65	73	S.	Cloudy ; rain.
	2	73	52		
	9	68	50		
19	6	66	41	WSW.	⊙ fhine ; clouds;rain; wind very high.
	1	71	27		
	10	66	61		
20	6	63	72	NW.	Fair, wind high ; Aurora Borealis.
	1	68	65		
	9	66	72		
21	6	61	88	W.	⊙ fhine and clouds ; at night, thunder and lightning; rain.
	1	70	68		
	9	67			
22	6	60	84	NW. W.	Fair ; cool ; very windy.
	2	74			
	9	72			
23	6	64	57	NW. W.	Fair, windy.
	1	68			
	10	66			
24	6	62	80	NW. W.	Fair ; cool air ; very drying wind.
	1	70			
	10	66	74		
25	7	67	80	SW.	Fair ; clouds ; thunder & light. windy.
	1	74			
	10	69	81		
26	6	64		SW. NE.	⊙ fhine ; clouds ; fmall rain.
	1	69			
	10	66	90		
27	7	63	82	NE.	Very rainy, wind high.
	2	63	80		
	9	60	85		
28	6	58	84	N.	Mifty.
	1	60	82		
	10	60	82		
29	6	60	82	SE. SW.	Mifty ; fmall rain.
	2	69	70		
	10	69	72		
30	6	67	78	SW.	Fair ; a very fine day.
	2	77	62		
	10	69	81		

Therm.	A.M.	Noon.	P.M.
Higheft,	70°	77°	73°
Loweft,	51	53	53
Mean ftat.	62	68	62

Barom.	A.M.	Noon.	P.M.
	30, 22	30, 06	30, 18
	29, 41	29, 27	29, 44
	29, 78	29, 69	29, 76

Plentiful rains. Grain, in general, very fine. Indian corn low for the feafon.—Very little thunder and lightning.

Difeafes in *Ipfwich* ; pleurifies, peripneumonies, worms, abfceffes, rheumatifms.
Difeafes in *Salem* ; fevers, diarrhœas, vomitings with purgings, pleurifies, ophthalmias, abfceffes, rheumatifms.
Difeafes in *Beverly* ; much the fame as in *Salem*.

Days.

Days.	H.	Ther.	Barom.	Wind.	Weather.
1	7	72	29,76	NE. SW.	Fair, a fine day.
	1	75	70		
	10	72	77		
2	6	69	84	W.	☉ſhine ; P. M. a thunder ſhower.
	1	77	60		
	9	72	70		
3	6	68	80	NW. SW.	Fair.
	1	76	62		
	10	70	76		
4	6	69	82	NNW.	☉ſhine and clouds ; briſk air.
	1	79	62		
	9	72	91		
5	7	68	30,00	NW. W.	Fair, ſultry.
	1	81	29,70		
	9	79	64		
6	6	75	85	N.	Smoky, cool breeze.
	1	74	85		
	9	69	90		
7	6	67	90	W.	Fair, ſmoky and ſultry.
	1	81	58		
	9	80	52		
8	6	76	59	WSW.	Hazy, very ſultry.
	1	86	28		
	10	82	19		
9	6	79	28	NW.	Fair.
	1	83	19		
	10	78	45		
10	6	74	72	NNE.	☉ſhine and clouds ; cool air.
	10	66	95		
11	6	67	96	NNE.	Miſty morn; ☉ſhine; cool air.
	2	69	97		
	10	66	30,05		
12	7	65	06	NNW. NE.	ſhine and clouds.
	2	70			
	10	66	00		
13	7	65	29,96	SSW.	Fair, very ſultry and dry.
	1	76	68		
	9	76	76		
14	6	70	82	W. SW.	Cloudy ; high wind.
	1	80	51		
	10	76	54		
15	6	76	50	SW. N.	Plentiful rain.
	1	75	24		
	10	74	59		
16	7	73	62	N.	Hazy.
	1	74	56		
	10	70	62		
17	7	70	29,60	NNW. N.	Miſt and rain.
	1	70	52		
	10	69	53		
18	7	70	56	W.	Fair, fine day.
	2	81	36		
	9	78	41		
19	7	69	67	NE.	Very rainy.
	1	68	66		
	9	65	71		
20	7	63	83	NW. SE.	Fair.
	2	70	72		
	9	77	85		
21	7	66	90	SE.	Fair.
	2	73	74		
	9	70	86		
22	7	66	95	WNW. S.	☉ſhine and clouds.
	3	75	76		
	10	71	81		
23	6	68	84	W.	☉ſhine and clouds.
	1	79	50		
	10	74	58		
24	6	70	61	SSW. S.	☉ſhine and clouds; a ſmall ſprinkling of rain.
	2	81	26		
	10	73	40		
25	6	71	48	WNW	Cloudy, ſmoky air.
	1	75	45		
	10	73	53		
26	7	69	72	NW. W.	☉ſhine and clouds.
	2	74	62		
	10	69	80		
27	6	69	90	N.	☉ſhine and clouds.
	2	74	80		
	10	70	82		
28	6	67	88	W. S.	☉ſhine and clouds.
	2	77	62		
	10	72	71		
29	7	68	78	SW.	Fair morn; cloudy afternoon.
	1	74	64		
	10	73	61		
30	6	72	60	W.	☉ſhine&clouds. P.M. a plentiful ſhow. of ra. without thun. or ligh.
	1	80	44		
	10	75	46		
31	6	72	54	WNW. W.	☉ſhine and clouds.
	2	79	36		
	10	75	41		

	Therm. A.M.	Therm. Noon.	Therm. P.M.	Barom. A. M.	Barom. Noon.	Barom. P.M.
Hig.	79°	86°	82°	30,06	29,97	30,05
Low.	63	68	65	29,28	29,19	29,19
M. ſtat.	70	76	72	29,75	29,57	29,68

The firſt part of the month very hot and dry ; the hot weather continued with repeated rains and great dews English grain, in general, very fine. Rye conſiderably injured by blaſt or mildew. Siberian wheat, which was ſowed in large quantities, almoſt totally ruined. English hay, plenty Indian corn, and flax, very good. Scarce any thunder and lightning.

Diſeaſes in *Ipſwich* ; bilious complaints, anaſarcas, worm caſes, a few fevers—Very healthy.
Diſeaſes in *Salem* ; diarrhœas vomitings, dyſenteries, anaſarcas, ophthalmias.
Diſeaſes in *Beverly* ; alvine fluxes, remittent and putrid fevers.

Days.	H.	Ther.	Barom.	Wind.	Weather.
1	7	71	29,56	NNE.	Fair ; very ſmoky P. M.
	1	74	53	NE.	
	9	71	68		
2	7	70	70	NNE.	Fair, ſmoky.
	1	75	63	SE.	
	9	69	81		
3	7	65	90	E.	Foggy morn; fair; at night rain.
	1	74	70	SE.	
	9	70	80		
4	7	70	80	SE.	⊙ ſhine and clouds, ſultry.
	1	77	65	SW.	
	10	76	68		
5	7	72	84	WNW.	⊙ſhine and clouds.
	2	80	60	SW.	
	10	74	75		
6	6	74	74	NW.	Fair; very ſultry. A very curious Aur. Borealis at night.
	1	82	51	SW.	
	10	78	50		
7	6	74	57		Fair, ſtill very ſultry.
	2	82	36	SW.	
	10	79	85		
8	7	76	85	W.	Fair; ther. out doors, and in the ſun, merc. rang. at 108° at 5 P. M.
	2	87	06	SW.	
	10	83	11		
9	6	75	39	W.	Fair, briſk air.
	2	80		SW.	
	10	77	41		
10	7	71	65		Fair ; briſk wind ; cool ; a very ſudden change in the weather
	1	72	62	NW.	
	9	69	90		
11	7	64	30,05	N.	Wind briſk ; ⊙ſhine and clouds.
	1	67	02	NW.	
	10	65	04		
12	7	61	38	E.	Cool, very ſmoky, clouds and ⊙ſhine.
	1	70		NE.	
	9	67	29,84		
13	7	69	46	SW.	Plentiful rain laſt night & this morn ; clouds and ⊙ ſhine.
	1	71	43	W.	
	10	69	52		
14	6	65	73		⊙ſhine ; Aurora Borealis at night.
	1	60	72	NW.	
	10	64	90		
15	7	62	30,06		Fair.
	1	69	29,95	NNW.	
	9	67	30,07		
16	6	62	14	E.	Foggy morn. ⊙ſhine
	2	70	02	SE.	
	10	65	10		
17	7	61	30,14	W.	Clouds and ⊙ſhine.
	2	68	00	SW.	
	9	67	00		
18	7	65	06	SW.	⊙ſhine.
	1	71	29,93	E.	
	10	67	30,00		
19	6	66	29,93		⊙ſhine and clouds, rain afternoon.
	1	73	73	E.	
	9	70	72		
20	7	69	50		Fair. Aur. Borealis which continued thro' the night.
	2	75	44	NNW.	
	9	70	70		
21	6	65	90		Very clear. Aurora Borealis at night.
	2	74	70	WNW.	
	9	71	72		
22	7	67	91		Fair. Aur. Borealis at night.
	2	78	60	SW.	
	10	72	74		
23	1	71	79		Cloudy.
	2	75	59	S.	
	10	73	62		
24	7	72	70		Clouds and ⊙ſhine.
	1	74	65	NNW.	
	10	70	84		
25	7	65	96		Clouds and ⊙ſhine.
	1	69	88	N.	
	9	65	95		
26	6	64	94		⊙ ſhine, clouds, rain at night.
	2	68	76	NNW.	
	9	68	72		
27	6	78	62	WNW.	Foggy morn; ⊙ſhine; ſhower at night.
	2	72	56	N.	
	9	69	69		
28	6	62	86	NW.	Fair.
	1	73		SW.	
	9	68	74		
29	6	68	69		Clouds and ⊙ſhine.
	1	72		SW.	
	9	71	78		
30	7	69	30,07		Clouds and ⊙ſhine.
	1	72	29,80	SW.	
	10	71	77		
31	6	71	69		Clouds ; plentiful ſhower.
	1	76	50	S.	
	10	69	73		

	Therm. A.M.	Therm. Noon.	Therm. P.M.	Barom. A. M.	Barom. Noon.	Barom. P. M.
Hig.	76°	87°	83°	30,14	30,02	30,10
Low.	61	67	64	29,39	29,06	29,11
M. ſtat.	68	74	70	29,81	29,66	29,67

The air frequently much loaded with vapour. Not an inſtance of thunder and lightning. Salt graſs well grown. Garden eſculents very plenty.

Diſeaſes in *Ipſwich* ; diarrhæas dyſenteries, cardialgias, anginas—Healthy.
Diſeaſes in *Salem* ; vomitings and purgings, coughs, abſceſſes, fevers, choleras, abortions.
Diſeaſes in *Beverly* ; putrid fevers, diarrhæas, and dyſenteries.

Days.

Days.	H.	Ther.	Barom.	Wind.	Weather.
1	6	63	29,93	WNW	Fair.
	2	69	82		
	9	66	90		
2	6	61	95	WNW. SW.	⊙ fhine and clouds.
	1	68	72		
	10	68	64		
3	6	66	69	SW.	⊙ fhine and clouds.
	1	76	44		
	9	72	45		
4	7	73	40	SW. NW.	⊙ fhine ; cloudy ; fmall rain.
	2	81	25		
	9	72	62		
5	6	65	30,00	NW.	⊙ fhine and clouds.
	1	70			
	9	63	27		
6	7	59	34	NW. W.	⊙ fhine and clouds.
	1	67	15		
	9	65	10		
7	7	65	00	S. SW.	⊙ fhine ; clouds ; rain at night with high wind.
	1	74	29,55		
	11	73	42		
8	7	70	58	WNW. NW.	Fair, windy.
	1	66	80		
	10	61	30,14		
9	8	58	14	NW.	Clear.
	2	64	20		
	9	62	28		
10	7	61	25	SW.	Fair.
	2	65	09		
	9	62	07		
11	7	62	29,92	SSW.	Clouds, rain.
	1	69	60		
	10	69	42		
12	7	63	69	SW.	Clouds, ⊙ fhine.
	1	64	70		
	9	62	83		
13	7	60	93	W. E.	⊙ fhine and clouds.
	2	66	82		
	10	62	92		
14	7	57	30,07	W.	Fair.
	1	69	29,92		
	10	65	30,05		
15	7	62	08	W.	Fair.
	1	74	29,76		
	10	69	80		
16	7	63	29,77	W.	⊙ fhine ; clouds ; windy ; rain at night.
	1	77	40		
	10	74	47		
17	6	66	82	NE. E.	⊙ fhine and clouds.
	1	61	98		
	10	56	30,03		
18	7	58	29,93	E. W.	Very rainy, with high wind; fair; bright Au. Borealis at night.
	1	60	70		
	9	61	62		
19	6	58	72	W. SW.	Very clear.
	2	71	48		
	10	70	50		
20	6	67	63	NW. NNW.	Cloudy, a little rain.
	1	59	96		
	9	57	30,01		
21	7	55	04	NW. N.	Cloudy, rain, fair.
	1	54	29,99		
	10	51	30,07		
22	6	47	21	NW.	Very fmall froft in the morn. ⊙ fhine and clouds; windy.
	2	53	13		
	10	54	20		
23	7	50	25	W.	Fair.
	2	63	29,93		
	9	63	94		
24	6	57	30,10	WNW.	Fair.
	1	68	29,91		
	9	63	30,00		
25	6	59	01	SW.	Fair, fine day. Aur. Borealis at night.
	2	74	29,50		
	9	70	60		
26	6	64	67	WNW.	Fair, wind very high.
	1	62	71		
	9	57	94		
27	7	52	98	NW. WSW.	⊙ fhine and clouds ; rain at night.
	1	58	81		
	10	57	66		
28	7	56	61	NW.	Fair, fine day.
	1	65	47		
	10	60	65		
29	7	55	74	NNW. NE.	⊙ fhine and clouds.
	2	60	60		
	9	60	54		
30	7	58	59	WNW. NNW.	⊙ fhine and clouds.
	2	58	74		
	9	55	30,03		

Therm.		A.M.	Noon.	P.M.
	Higheft,	73°	77°	77°
	Loweft,	47	53	51
	Mean ftat.	60	66	63

Barom.	A. M.	Noon.	P. M.
	30, 34	30, 20	30, 20
	29, 40	29, 25	29, 48
	29, 90	29, 76	29, 84

Very little rain. Fine weather for ripening Indian corn, and making falt hay, of which there are good crops. Garden-fruit plenty.

Difeafes in *Ipfwich* ; diarrhœas, dyfenteries, vomitings—Very healthy.
Difeafes in *Salem* ; dyfenteries, vomitings and purgings, choleras, abfceffes, diarrhœas.
Difeafes in *Beverly* ; dyfenteries and diarrhœas, low fevers.

Days.	H.	Ther	Barom.	Wind.	Weather.
1	8	48	30,26	NNW.	Fair ; a ſmall froſt this morning.
	2	54	20	SW.	
	10	52	20		
2	8	55	24	SE.	⊙ ſhine and clouds ; rain at night.
	2	61	29,98		
	9	60	92		
3	7	59	90	NW.	Foggy ; fair ; ſhower at 5 o'clock.
	1	62	83		
	9	58	30,00		
4	7	49	31	NW.	⊙ ſhine and clouds.
	2	50	40		
	9	48	55		
5	7	40	68	W.	Fair. Water a little frozen this morn.
	1	49	45	SW.	
	10	52	30		
6	7	51	25	W.	Fair.
	2	60	29,98		
	9	55	30,06		
7	7	53	24	N.	Clouds and briſk wind.
	1	53	36		
	9	51	46		
8	8	43	58	NNW.	Fair. Small Aur. Borealis at night.
	2	53	38	SW.	
	10	48	28		
9	7	46	14	NW.	Fair.
	1	59	29,90		
	10	59	97		
10	7	52	30,06	W.	Fair.
	1	63	29,80	SW.	
	9	66	76		
11	7	61		W.	Fair.
	2	70		SW.	
	9	68	74		
12	8	63	80	SW.	Several ſhowers ; ſome thun. & ligh.
	2	72	55		
	9	69	52		
13	7	63	49	SW.	⊙ ſhine, clouds ; rain P.M. with thun. and ligh. & high wind.
	2	69	17	W.	
	9	67	20		
14	7	50	65	WNW.	Clouds and ⊙ ſhine.
	1	54	72		
	9	59	82		
15	7	56	95	SW.	Fair ; at night a very curious Aur. Bor.
	2	69	83		
	11	61	30,00		
16	7	60	00	SW.	⊙ ſhine and clouds ; very briſk wind.
	1	68	29,75		
	10	65	63		
17	7	57	29,80	WSW.	Rainy morning, fair.
	1	51	87	W.	
	10	51	94		
18	7	46	30,01	NNE.	Clouds ; rain P.M. & thunder at night.
	1	52	29,96	NE.	
	10	51	30,00		
19	7	49	07	NW.	Clouds and ⊙ ſhine. Faint Au. Bor. at nig.
	2	51	03	NE.	
	11	46	13		
20	7	44	06	SW.	⊙ ſhine & clouds ; at night thun. & light.
	2	50	29,73		
	10	56	59		
21	7	54	57	WSW.	⊙ ſhine and clouds, fine day.
	2	56	48		
	10	54	66		
22	8	51	95	NW.	⊙ ſhine and clouds.
	1	53	96		
	10	50	30,19		
23	7	44	37	NW.	⊙ ſhine and clouds.
	1	48	29	E.	
	10	48	27		
24	7	49	06	SSW.	Clouds, rain aftern.
	1	57	29,67	WNW	
	10	54	61		
25	7	46	94	WNW	Fair, fine day.
	2	49	94		
	10	45	30,14		
26	7	44	14	N.	Clouds, rainy aftern.
	2	48	05	NE.	
	10	51	29,92		
27	7	49	30,10	NNW.	Clouds and ⊙ ſhine.
	2	54	13		
	10	50	32		
28	7	46	46	N.	Clouds and ⊙ ſhine.
	2	49	40		
	8	47	36		
29	7	45	22	NW.	Moderate rain.
	2	48	00	N.	
	9	45	29,95		
30	8	42	92	W.	Fair, briſk wind.
	1	47	82		
	10	45	93		
31	7	40	30,02	SW.	Fair, fine day.
	2	57	29,87		
	9	52	94		

	Therm. A.M.	Therm. Noon.	Therm. P.M.	Barom. A.M.	Barom. Noon.	Barom. P.M.
Hig.	63°	72°	69°	30,68	30,45	30,55
Low.	40	47	45	29,49	29,17	29,20
M. ſtat.	50	56	54	30,01	29,93	29,97

More thunder and lightning in this month than during the whole ſummer. Several froſts ; but many of the more hardy flowers ſtill remain uninjured. Garden eſculents plenty. Indian corn well ripened, and a good crop.

Diſeaſes in *Ipſwich* ; a very few dyſenteries and diarrhœas, low fevers—Very healthy.
Diſeaſes in *Salem* ; dyſenteries, vomitings and purgings, choleras, abſceſſes, diarrhœas, fevers, abortions.
Diſeaſes in *Beverly* ; bilious cholics, ſome nervous fevers.

Days

Days.	H.	Ther.	Barom.	Wind.	Weather.
1	8	48	30,04	N.	Cloudy ; very great quantity of rain at night ; wind high.
	2	51	29,93		
	10	53	66		
2	7	52	55	SW. E.	Misty ; at night very rainy.
	1	54	60		
	9	53	70		
3	8	50	60	N.	Very rainy, high wind.
	1	49	51		
	10	48	60		
4	7	45	63	NW.	Cloudy.
	1	46	62		
	9	46	71		
5	7	41	73	NW.	Blustering & squally.
	1	40	71		
	10	40	72		
6	7	39	74	NW.	Cloudy & blustering.
	2	43	71		
	10	44	75		
7	9	46	72	NW.	Fair and very pleasant.
	1	47	62		
	10	44	8[illegible]		
8	7	40	8[illegible]	W. NW.	Very blustering and squally.
	1	43	70		
	10	40	8[illegible]		
9	9	35	97	NW.	Very chilly and blustering.
	1	36	92		
	9	33	92		
10	8	31	30,0[illegible]	NW.	Fair, windy and chilly.
	1	36	02		
	10	37	10		
11	8	33	12	NW.	Fair.
	1	35	10		
	9	37	03		
12	8	35		NE.	Stormy.
	1	40	29,83		
	10	40	79		
13	9	38	83	NNE.	Cloudy and very chilly.
	1	40	93		
	10	39			
14	8	38	30,7	NNE.	Cloudy.
	2	39	10		
	10	39	12		
15	8	37	17	NW.	Cloudy.
	2	40	10		
	11	37	30		
16	8	35	30,40	WNW.	Fair, Aur. Borealis at night.
	2	41	32		
	10	40	33		
17	8	37	33	SSE. NE.	☉shine and clouds.
	1	40	23		
	9	41	07		
18	8	42	29,90	N. NW.	Clouds and ☉shine.
	1	42	92		
	9	42	30,03		
19	8	39	07	W. WSW.	Fair. Small Aurora Borealis at night.
	2	44	29,95		
	11	44	30,07		
20	8	35	26	NW.	☉ shine and clouds.
	1	36	28		
	10	35	50		
21	8	30	55	NW. NE.	Cloudy ; at night snow, which fell about 6 inches deep.
	2	35	36		
	9	35	21		
22	8	32	29,92	NW. WSW.	Clouds and ☉shine.
	1	34	86		
	10	34	86		
23	8	32	30,16	W.	Fair.
	2	32	30		
	10	29	58		
24	9	23	84	NW.	Fair.
	2	29	80		
	10	29	80		
25	8	27	70	SW.	Cloudy ; very rainy night.
	1	33	48		
	9	40	07		
26	8	40	29,33	SSE. NW.	Cloudy, rain.
	2	45	40		
	10	35	30,02		
27	8	26	26	NW.	Fair, brisk wind.
	1	30	36		
	11	32	50		
28	8	26	62	N. NE.	Cloudy ; wind high ; at night very rainy.
	1	33	52		
	11	37	23		
29	8	43	29,50	E. NW.	Rainy & blustering.
	2	43	41		
	11	37	67		
30	8	34	96	W.	Fair and pleasant.
	1	39	30,06		
	10	38	22		

		A. M.	Noon.	P. M.
Therm.	Highest,	52°	54°	53°
	Lowest,	23	29	29
	Mean stat.	37	40	39

		A. M.	Noon.	P. M.
Barom.	Highest	30,84	30,80	30,80
	Lowest	29,33	29,40	29,60
	Mean	30,03	29,99	30,01

The greater part of this month very windy, cold and stormy.

Diseases in *Ipswich* ; some low fevers, coughs and colds.
Diseases in *Salem* ; pleurisies, abscesses, anasarcas, coughs, ophthalmias.
Diseases in *Beverly* ; cholics, coughs, some febrile complaints—Healthy.

Days.	H.	Ther.	Barom.	Wind.	Weather.
1	8	36	30,30	NNW. NE.	⊙ ſhine and clouds.
	2	41	23		
	10	41	25		
2	8	38	20	NNW.	⊙ ſhine and clouds, very bluſtering.
	1	40	14		
	10	39	25		
3	9	37	17	NNW.	Sprinkling of ſnow, and then rain.
	1	37	14		
	10	38	20		
4	8	34	33	WNW.	⊙ ſhine and clouds.
	2	41	28		
	10	40	21		
5	8	40	29,73	NE. NW.	Very ſevere ſtorm of rain, with high wind.
	2	41	41		
	11	38	62		
6	8	35	82	W.	⊙ ſhine & clouds.
	1	36	82		
	11	38	80		
7	9	37	70	N. NW.	A ſprinkling of ſnow laſt night.
	1	38	64		
	11	38	80		
8	8	33	30,03	W.	⊙ ſhine & clouds.
	2	34	03		
	11	37	23		
9	8	31	26	W.	⊙ ſhine and clouds; ſnow at night.
	1	34	17		
	10	36	04		
10	8	36	29,46	NNE. W.	Snow, rain & hail.
	1	35	30		
	10	31	55		
11	8	27	72	WSW.	Fair. Aurora Borealis at night.
	2	32	68		
	11	30	74		
12	8	27	68	SW.	⊙ ſhine and clouds.
	2	30	60		
	11	31	70		
13	8	29	72	SW.	Fair and pleaſant.
	2	34	70		
	9	37	80		
14	8	31	95	SW.	Fair, pleaſant.
	1	34	91		
	10	33	96		
15	8	27	98	W.	Fair.
	2	31	90		
	10	30	30,00		
16	8	22	18	WNW. N.	Clouds, ſprinkling of ſnow at night.
	2	26			
	10	29	11		
17	8	21	30,30	NW.	⊙ ſhine and clouds.
	2	26			
	9	31	40		
18	8	29	47	NNW. NW.	⊙ ſhine and clouds.
	2	30	67		
	9	27	70		
19	9	20	74	W. S.	Clouds and ⊙ ſhine.
	2	31	57		
	10	33	47		
20	8	37	29,81	SE. NW.	Fog and miſt. Moſt of the ſnow gone at night.
	1	41	50		
	11	40	80		
21	9	31	30,35	NW.	Fair.
	1	30	50		
	11	28	72		
22	8	24	70	W. SW.	Fair.
	1	27	60		
	10	30	50		
23	8	28	48	NW.	Fair.
	1	35	41		
	9	36	52		
24	8	28	69	N.	Cloudy & bluſtering
	2	27	66		
	9	24	62		
25	8	22	70	NW.	Fair.
	2	26	69		
	11	24	78		
26	8	21	78	WNW. W.	Fair.
	1	26	64		
	11	32	45		
27	9	30	30	SW.	Cloudy and miſty.
	1	32	20		
	10	36	04		
28	8	35	29,80	N. NE.	Very rainy.
	2	38	24		
	11	37	60		
29	8	35	82	S. W.	Small quantity of ſnow.
	2	38	40		
	10	38	40		
30	8	34	30,20	WNW.	Fair and pleaſant.
	1	37	26		
	10	35	44		
31	8	32	40	NNW. SE.	Snow and rain; foggy at night.
	2	36	10		
	11	38	29,73		

	Therm. A.M.	Therm. Noon.	Therm. P.M.	Barom. A.M.	Barom. Noon.	Barom. P.M.
Hig.	40°	41°	40°	30,78	30,69	30,78
Low.	20	26	24	29,46	29,24	29,40
M. ſtat.	30	34	34	30,15	30,01	30,11

The ground covered with a ſmall quantity of ſnow during the month; but not more than three or four inches deep at any one time.

Diſeaſes in *Ipſwich*; colds, abſceſſes, coughs, pulmonary conſumptions.
Diſeaſes in *Salem*; pleuriſies, catarrhal fevers, anginas, abſceſſes, coughs, cholics, anaſarcas,
Diſeaſes in *Beverly*; chronic rheumatiſms, bilious cholics.

Thermometer.

1781.	Thermometer. Greatest Height.	Least Height.	Mean Height.	Barometer. Greatest Height.	Least Height.	Mean Height.
January,	49	18	34			
February,	45	14	32			
March,	50	24	38			
April,	58	37	46			
May,	77	42	57			
June,	77	51	64	30, 22	29, 27	29, 74
July,	86	63	73	30, 06	29, 19	29, 67
August,	87	61	71	30, 15	29, 06	29, 74
September,	77	47	69	30, 34	29, 25	29, 83
October,	72	40	53	30, 68	29, 17	29, 97
November,	54	23	39	30, 84	29, 33	30, 01
December,	41	20	33	30, 78	29, 24	30, 09
Whole Year,	87	14	51			

1782.

JANUARY.

	Therm. A. M.	Noon.	P. M.	Barom. A. M.	Noon.	P. M.
Highest,	44	45	44	30, 88	30, 87	30, 83
Lowest,	6	10	7	29, 92	29, 90	29, 92
Mean stat.	26	28	25	30, 37	30, 36	30, 39

The weather variable---frequent snows and rains. Predominant winds from W. to N. E. The mercury in the barometer ranged exceeding high. On the 23d, a severe snow-storm, in which the snow fell twenty inches deep---wind N. E. The two last days intensely cold. Forty-four inches of snow fell during the month---the ground constantly covered. Fourteen days of falling weather.

Greatest degree of heat on the 4th, at 1, P. M.---barom. at 30, 25---wind W.---fair. Greatest deg. of cold on the 31st, at 8, A. M.---barom. at 30, 87---wind S. W.---fair. Barom. highest on the 2d, at 8, A. M.---therm. 24°---wind N.---fair: lowest on the 25th, at 2, P. M.---therm. at 22°---wind S.S.W. ---fair.

In

In the evening of the 2d, a faint Aurora Borealis----wind S. W.---ſnowed the preceding day in the morn.---the following rainy. Another in the night of the 9th---wind N. W.---preceding day miſty---ſnowed on the four following days.

Diſeaſes in *Ipſwich* ; rheumatiſms, palſies, coughs, ophthalmias : In *Salem* ; cholics, catarrhal fevers, ophthalmias, coughs and defluctionary diſorders : In *Beverly* ; worms, peripneumonies and other pulmonic diſorders.

FEBRUARY.

	Therm. A. M.	Therm. Noon.	Therm. P. M.	Barom. A. M.	Barom. Noon.	Barom. P. M.
Higheſt,	37	40	39	30, 99	30, 93	30, 83
Loweſt,	6	15	18	29, 84	29, 62	29, 90
Mean ſtat.	27	30	30	30, 38	30, 32	30, 33

Bluſtering, ſtormy and cold----few pleaſant days----ground covered with a conſiderable depth of ſnow. Predominant winds from W. to N. E. Eight days of falling weather. Fifteen inches of ſnow fell during the month.

Greateſt deg. of heat on the 22d, at 2, P. M.----barom. at the loweſt---wind S. W.---cloudy. Greateſt deg. of cold on the 1ſt, at 8, A. M.---barom. higheſt---wind N. W.---fair.

An Aurora Borealis in the evening of the 6th---wind N.---the preceding and following days fair ; but on the third and fourth days after, it ſnowed.

Diſeaſes in *Ipſwich* ; worm caſes, pleuriſies—Very healthy : In *Salem* ; cholics, anginas, pleuriſies, rheumatiſms, ſcrophulas : In *Beverly* ; pulmonic diſeaſes, ſmall pox.

MARCH.

	Therm. A. M.	Therm. Noon.	Therm. P. M.	Barom. A. M.	Barom. Noon.	Barom. P. M.
Higheſt,	43	50	44	30, 68	30, 70	30, 60
Loweſt.	21	31	33	29, 66	29, 63	29, 43
Mean ſtat.	35	40	37	30, 09	29, 99	30, 09

The

The weather, in general, mild. Predominant winds from S. W. to N. Small quantity of ſnow with rain fell on the 11th. The ground moſtly bare by the middle of the month. The latter part of the month windy. Six rainy days, in which a large quantity of rain fell ; but no ſevere ſtorm. Grain appears to have been very little injured by the winter.

Greateſt deg. of heat on the 14th, at 1, P. M.---barom. 30, 02---wind S. W.---ſunſhine and clouds. Greateſt deg. of cold on the 4th, at 7, A. M.---barom. at 30,58---wind N. W.---fair. Barom. higheſt on the 8th, at 2, P. M.---therm. at 38° ---wind N. E.---cloudy : loweſt on the 27th, at 9, P. M.---therm. at 42°---wind high at S. W.---cloudy.

A faint Aurora Borealis on the 9th at night---wind W.---preceding day fair---on the following, rain and ſnow. On the 14th, a bright parhelion, ſouth of the ſun, at 7, A. M. In the morning of the 18th, very ſevere thunder---two houſes, a barn and many trees ſtruck with the lightning in this town.

Diſeaſes in *Ipſwich* ; cholera morbus, pulmonary conſumptions, rheumatiſms, colds, coughs, ophthalmias, ſcrophulas : In *Salem* ; ophthalmias, ſcrophulas, bad coughs : In *Beverly* ; remitting fevers.

APRIL.

	Therm.			Barom.		
	A. M.	Noon.	P. M.	A. M.	Noon.	P. M.
Higheſt,	56	68	62	30, 53	30, 48	30, 50
Loweſt,	39	43	41	29, 65	29, 67	29, 66
Mean ſtat.	46	52	49	29, 98	30, 01	30, 05

The firſt part of the month, warm and pleaſant. Vegetation advanced with great rapidity. The wind frequently between E. and S. and between S. and W.---though it prevailed moſtly between W. and N. But from the 16th to the end

end of the month, the wind was, for the moſt part, northerly, very high, and frequent cold ſtorms of rain. Twelve days on which rain fell. From the 19th to the 25th, wind conſtantly N. E. and more or leſs rain fell every day.

Greateſt deg. of heat on the 15th, at 2, P. M.---barom. at 29, 84---wind S.---fair. Greateſt deg. of cold on the 11th, at 6, A. M.----barom. 30, 59----wind N. N. E.----cloudy. Barom. higheſt on the 26th, at 6, A. M.----therm. 43°----wind N. N. W.---cloudy : loweſt on the 4th, at 6, A. M.---therm. 51°----wind very high at W. N. W.----clouds and ſunſhine.

The Aurora Borealis appeared in the night of the 2d,---wind W.---and of the 4th,---wind W. N. W.---the preceding and following days fair.—Wind very high on the 5th and 6th. Another Aurora in the night of the 14th,---wind W. S. W.---preceding and following days fair.

Diſeaſes in *Ipſwich* ; putrid and ſlow fevers, dyſenteries, cholics—Sickly : In *Salem* ; chin coughs, cholics, ophthalmias, pleuriſies, peripneumonies, rheumatiſms, catarrhal fevers—Very ſickly : In *Beverly* ; diſorders in the firſt paſſages, tumors.

MAY.

	Therm.			Barom.		
	A.M.	Noon.	P.M.	A. M.	Noon.	P. M.
Higheſt,	61	68	63	30, 32	30, 30	30, 28
Loweſt,	47	47	47	29, 28	29, 34	29, 60
Mean ſtat.	54	59	56	29, 91	29, 90	29, 95

The month very cool and wet---no froſt. Prevailing winds from W. to N. and N. E. Vegetation backward. Peach, and ſome other fruit-trees, injured by the winter. Fourteen days on which rain fell.

Greateſt

Greatest deg. of heat on the 12th, at 1, P. M.---barom. 29, 65---wind N.W.---fair. Greatest deg. of cold on the 4th--- the mercury ranged at the same height morning, noon and night ---barom. rose from 29, 61 to 29, 80---wind N.---clouds and rain. The night was very remarkably light, although it was cloudy and no moon; probably occasioned by a very bright Aurora Borealis. Barom. highest on the 17th, at 1, P. M.--- therm. 53°---wind N.E.---fair: lowest on the 10th, at 6, A.M. ---therm. 58°---wind N. W.---fair.

An Aurora Borealis in the night of the 5th---wind N.N.W. —of the 6th---wind S. W.—of the 9th---wind S. S. W.— and of the 22d---wind S. W. Rain on the preceding and following days of the four first; fair weather preceding and following the last of them. Thunder and lightning on the 13th.

Diseases in *Ipswich*; convulsions, bilious cholics, putrid fevers, worms: In *Salem*; chin coughs, cholics, catarrhal fevers, convulsions—Sickly: In *Beverly*; pulmonic fevers, worms.

JUNE.

	Therm.			Barom.		
	A. M.	Noon.	P. M.	A. M.	Noon.	P. M.
Highest,	80	88	81	30, 43	30, 31	30, 39
Lowest,	54	62	56	29, 27	29, 10	29, 23
Mean stat.	66	75	70	29, 79	29, 62	29, 76

Predominant winds from S. W. to N. W. Frequent mild showers—very little thunder and lightning—only one whole day cloudy during the month. From the 15th to the 24th, extremely sultry. The weather exceedingly favourable to vegetation. All kinds of corn, grass and garden-productions, promise plentiful crops. Little injury done by insects and rep-

tiles, except canker-worms on apple-trees; by which many orchards, for years past, have not only been deprived of fruit, but the trees almost destroyed.*

Greatest deg. of heat on the 22d, at 1, P. M.---barom. 29, 10---wind W. S. W.--- sunshine and clouds. Greatest deg. of cold on the 8th, at 6, A. M.---barom. 30, 36---wind high at S. W.---fair. Barom. highest on the 9th, at 7, A. M.---therm. 50°---wind S. W.----fair: lowest on the 23d, at 1, P. M.---therm. 71°---wind high at S. S. E.---heavy shower of rain.

Northern lights in the evenings of the 5th and 6th---wind W. N. W.----on the 3d and 4th, showers of rain----the six following days fair. Distant lightning on the 6th----thunder and lightning on the 19th, 22d and 23d.

Diseases in *Ipswich*; slow fevers, worms, rheumatisms, pleurisies, pulmonary consumptions: In *Salem*; chin coughs, and

* Among the many experiments that have been made for destroying canker-worms, tarring round the body of the trees seems to have been the most effectual: but if the tar be applied on the bark, it will injure the trees, especially if they are young, nearly as much as the worms. This injury, however, may be entirely prevented, and the worms more effectually destroyed, by putting, next the bark, a clay morter well mixed with hair or chopped straw, about an inch thick; upon the morter a strip of canvass or birch bark: then take a large rope of swingled tow, twisted by hand, and make two or three turns round the tree, below and close to the canvass, drawing it tight upon the moist morter to prevent the tar from running down. Let the canvass be tarred every day, just before sunset, from the time the snow is gone under the trees, in the spring, until no worms are found on the tar. When the worms have done passing, the whole is to be removed from the trees. By this method much less tar is used; and it has been found, by repeated experiments, that the worms will be destroyed in two years without the least injury to the trees. But compleat success is not to be expected, unless the trees are tarred as soon as the snow, if it lays late in the spring, is melted away about their bodies, and faithfully continued, every day, until the worms have done passing.

and vomitings and purgings among children: In *Beverly*; chronic diforders.

JULY.

	Therm.			Barom.		
	A. M.	Noon.	P. M.	A. M.	Noon.	P. M.
Higheft,	79	84	80	30, 05	29, 81	30, 00
Loweft,	61	68	60	29, 21	29, 06	29, 15
Mean ftat.	69	71	66	29, 64	29, 42	29, 57

The whole of the month, efpecially the latter part, very dry. A few fmall fhowers of rain. Frequent heavy fogs, and cool nights. Winds principally from W. to N. Siberian wheat entirely deftroyed by a blaft or mildew---rye in general fhared the fame fate—oats and barley greatly injured----Indian corn, and the later garden efculents fuffered from the drought and cold ---plentiful crops of Englifh hay.

Greateft deg. of heat on the 15th, at 2, P. M.----barom. loweft---wind S. W.---funfhine and clouds. Greateft deg. of cold on the 20th, at 9, P. M.---barom. 29, 61---wind S. W. ---fair. Barom. higheft on the 20th, at 8, A. M.----therm. 68°---wind S. W.---cloudy.

Northern light in the evening of the 9th---wind S. W.--- the preceding night rain----the following days fair and cool: alfo, in the evening of the 20th---wind S. W. --preceding days fair---the third day after, rain. Thunder and lightning on the 24th.

Difeafes in *Ipfwich*; diarrhæas, pleuritic fevers: In *Salem*; putrid fevers, cholics, vomiting blood, chin cough, choleras, vomiting and purging among children: In *Beverly*; worm fevers.

AUGUST.

	Therm.			Barom.		
	A.M.	Noon.	P.M.	A. M.	Noon.	P. M.
Higheſt,	79	85	76	30, 30	30, 12	30, 22
Loweſt,	55	66	61	29, 26	29, 20	29, 37
Mean ſtat.	67	73	69	29, 82	29, 65	29, 85

Very dry---ſmall ſhowers of rain on the 3d, 10th, 13th, 19th and 26th. Foggy nights and mornings from the 18th to the 27th. Winds very variable---prevailed moſtly from W. to N. Indian corn and garden vegetables ſuffered by the drought. Paſtures exceedingly dried up. Salt graſs very good.

Greateſt deg. of heat on the 9th, at 2, P. M.----barom. loweſt---wind S.W.---fair. Greateſt deg. of cold on the 13th, at 7, A. M.---barom. higheſt---wind W.---fair.

Faint northern lights in the evenings of the 26th and 28th, ---wind N. W.----fair and cool after them. On the 9th, a few claps of thunder, with lightning.

Diſeaſes in *Ipſwich* ; dyſenteries, ſlow fevers, worm caſes : In *Salem* ; cholera morbus, chin coughs, mild dyſenteries, vomiting and purging among children : In *Beverly* ; cholera morbus.

SEPTEMBER.

	Therm.			Barom.			
	A. M.	Noon.	P.M.	A. M.	Noon.	P. M.	
Higheſt,	74	86	78	30, 40	30, 22	30, 25	Rain.
Loweſt.	47	56	51	29, 51	28, 97	29, 56	Inch.
Mean ſtat.	59	67	59	30, 02	29, 80	29, 95	0,703

Winds variable, and frequently very high---prevailed moſtly between S. and N. W. The drought extremely ſevere---only four very ſmall ſhowers during the month. The dews were commonly large, and preſerved the verdure of ſome kinds of vegetables. In the latter part of the month, the atmoſphere

conſtantly

conſtantly loaded with a ſmoky vapour. The ground, in many places, ſaid to be dried to a mere duſt, as low as four or five feet from the ſurface. The withered ſtate of many large groves of trees, exhibit a melancholy evidence of the extreme dryneſs of the ground. Fields of Indian corn as white as they uſually are the laſt of October, with their ears hanging down, and huſks ſeparated. All kinds of garden eſculents greatly ſuffered, and many of them periſhed. Horſes and cattle fed at barns before the middle of the month.

Greateſt deg. of heat on the 5th, at 3, P.M.---barom. loweſt ----wind extremely high at S. W. The mercury fell three-fourths of an inch from 7 in the morning to 3 in the afternoon, and, as the wind abated, roſe as much in about ſix hours. Greateſt deg. of cold on the 27th, at 7, A. M.---barom. 30, 10---wind W. N. W.---fair. Barom. higheſt on the 14th, at 6, A. M.---therm. 54°---wind W.---ſmoky air.

Frequent northern lights, viz. in the evening of the 5th, ſmall---wind W.—the 6th ; wind E.---rain the next day :—the 12th, very bright ; wind W.----cool the next day :—the 13th ; wind N. N. W.---rain the next day :—the 15th ; wind N. W.---fair after it :—the 22d ; wind S. W.---fair after it :—the 30th ; wind N. W.---ſprinkling of rain next day.

Diſeaſes in *Ipſwich* ; continued fevers, worms : In *Salem* ; cholera morbus, chin coughs, mild dyſenteries, vomiting and purging among children : In *Beverly* ; ſlow fevers, cholera morbus.

OCTOBER.

	Therm. A. M.	Therm. Noon.	Therm. P. M.	Barom. A. M.	Barom. Noon.	Barom. P. M.	
Higheſt,	59	64	62	30, 52	30, 51	30, 50	Rain.
Loweſt,	42	45	44	29, 62	29, 59	29, 60	Inch.
Mean ſtat.	49	53	51	30, 08	29, 97	30, 08	3,133

Frequent

Frequent mild rains. Predominant winds from S. W. to N. W. In the night of the 5th, water froze abroad. On the 17th and 18th, wind exceſſive high, with rain and hail. Fifteen days on which rain fell.

Greateſt deg. of heat on the 3d, at 1, P. M.---barom. 29, 75---wind W.---fair. Greateſt deg. of cold on the 5th, at 7, A. M.- --wind E. N. E.----cloudy. Barom. higheſt on the 28th, at 7, A. M.---therm. 43°---wind N. W.---fair : loweſt on the 6th, at 1, P. M.---therm. 63°---wind N. W.---fair.

Frequent northern lights in the firſt part of the month----wind between S. W. and N. W.---rain within two or three days after each of them.

Diſeaſes in *Ipſwich* ; chin coughs, continued and putrid fevers, worms : In *Salem* ; dyſenteries, rheumatiſms, ſlow fevers, mumps : In *Beverly* ; ſlow fevers.

NOVEMBER.

	Therm.			Barom.			
	A. M.	Noon.	P. M.	A. M.	Noon.	P. M.	Rain.
Higheſt,	51	55	54	30, 88	30, 85	30, 76	Inch.
Loweſt,	22	24	27	29, 51	29, 55	29, 50	
Mean ſtat.	37	41	41	30, 15	30, 12	30, 09	4,533

Predominant winds from S. W. to N. W. Frequently cloudy. A ſtorm of ſnow on the 21ſt---wind N.---ſnow fell four and an half inches deep. The ground very little froze, and the ſnow melted in a few days. Nine days of falling weather.

Greateſt deg. of heat on the 7th, at 2, P.M.---therm. loweſt----wind S. W.----cloudy. Greateſt deg. of cold on the 29th, at 8, A.M.---barom. 30,60---wind W.---fair. Barom. higheſt on the 10th, at 8, A. M.---therm. 33°---wind N.---fair.

The

The Aurora Borealis appeared only in the evening of the 26th---wind W. N. W.---cold and windy after it.

Diseases in *Ipswich*; rheumatisms, cholics: In *Salem*; slow fevers, rheumatisms, erysipelas, mumps, cholics: In *Beverly*; hæmoptoes, worms.

DECEMBER.

	Therm.			Barom.			
	A.M.	Noon.	P.M.	A. M.	Noon.	P. M.	
Highest,	50	53	50	30, 75	30, 71	30, 83	Rain.
Lowest,	17	21	14	29, 37	29, 50	29, 56	Inch.
Mean stat.	35	37	34	30, 15	30, 09	30, 15	3,601

The weather, in general, pleasant; the air, on many days, as pleasant as in April or May. Prevailing winds from S. W. to N. W. The ground bare and very little froze. Snow fell three inches deep on the 30th and 31st. Seven days of falling weather.

Greatest deg. of heat on the 4th, at 2, P. M.---barom. 29, 92---wind S. W.---fair. Greatest deg. of cold on the 15th, at 10, P. M.----barom. 30, 73---wind N. N. W.----fair. Barom. highest on the 8th, at 10, P. M.----therm. 37°----wind W. N. W.---fair: lowest on the 31st, at 10, P. M.---therm. 37°---wind N. W.---snowed.

Diseases in *Ipswich*; pulmonary consumptions, hæmoptoes —Very healthy: In *Salem*; slow fevers, pleurisies, rheumatisms, bad coughs, putrid sore throats: In *Beverly*; cholics, tooth-ach, coughs, &c.

Thermometer.

1782.	Thermometer. Greatest Height.	Least Height.	Mean Height.	Barometer. Greatest Height.	Least Height.	Mean Height.	Rain. Inches.
January,	45	6	26	30, 88	29, 90	30, 37	
February,	40	6	29	30, 99	29, 62	30, 34	
March,	50	21	37	30, 70	29, 43	30, 06	
April,	68	39	49	30, 53	29, 65	30, 01	
May,	68	47	56	30, 32	29, 28	29, 92	
June,	88	54	70	30, 43	29, 10	29, 72	
July,	84	60	69	30, 05	29, 06	29, 54	
August,	85	55	70	30, 30	29, 20	29, 77	
September,	86	47	62	30, 40	28, 97	29, 92	0,703
October,	64	42	51	30, 52	29, 59	30, 04	3,133
November,	55	22	40	30, 88	29, 50	30, 12	4,533
December,	53	17	35	30, 83	29, 37	30, 13	3,601
Whole Year,	88	6	50	30, 99	28, 97	29, 99	11,970 Since Aug.

1783.

JANUARY.

	Therm. A.M.	Noon.	P.M.	Barom. A. M.	Noon.	P. M.	
Highest,	42	46	45	30, 90	30, 86	30, 82	Rain.
Lowest,	7	12	14	29, 48	29, 41	29, 42	Inch.
Mean stat.	28	32	32	30, 10	30, 05	30, 06	4,033

The state of the atmosphere variable, and our feelings very disagreeably affected by the constant vicissitudes of a mild and extreme cold air. The wind frequently between N. and N.E. and between S. W. and W. but prevailed mostly between W. and N. W. On the 8th, at 9, P. M. the therm. abroad, 5° below 0, and, at 8 the next morning, 10° below 0. The ground covered with snow from the 5th to the end of the month. A severe snow-storm on the 10th, with N. E. wind. Eleven days of falling weather. Snow fell twenty-three inches in the month.

Greatest deg. of heat on the 25th, at 1, P. M.---barom. 29, 68---wind W. S. W.----fair. Greatest deg. of cold on the 9th,

9th, at 8, A. M.---barom. higheſt----wind W. N. W.---fair. Barom. loweſt on the 19th, at 1, P. M.---therm. 44°---wind S. W.---fair.

An Aurora Borealis in the night of the 26th---wind N. W. preceding days fair---the four following, cold, with ſprinklings of ſnow.

Diſeaſes in *Ipſwich*; pleuritic fevers, anginas, coughs, tooth-achs: In *Salem*; bad coughs, anginas, tooth-achs, rheumatiſms, pleuritic fevers: In *Beverly*; remitting fevers, and nervous.

FEBRUARY.

	Therm.			Barom.			
	A.M.	Noon.	P.M.	A. M.	Noon.	P. M.	
Higheſt,	51	53	52	30, 84	30, 61	30, 83	Rain.
Loweſt,	1	12	10	29, 76	29, 64	29, 73	Inch.
Mean ſtat.	34	37	37	30, 28	30, 19	30, 26	4,907.

The weather more capricious than the laſt month. The varieties of cold, warm, fair, cloudy, rainy, ſnowy and foggy weather were experienced every few days through the month. on the 3d, at 8, A. M. the therm. out doors, ſtood at 8° below 0. Farmers plowed on the 21ſt. Winds variable, but moſt prevalent from S. W. to W. Ground covered with ſnow until the 18th. A very denſe ſmoke-like fog in the evening of the 10th, attended with a ſingular kind of ſcent, ſomewhat reſembling that of burned leaves. Thirteen days of cloudy and falling weather. Ten inches of ſnow fell during the month.

Greateſt deg. of heat on the 19th, at 2, P. M.----barom. loweſt---wind S. S. W.---miſty. Greateſt deg. of cold on the 3d, at 7, A. M.---barom. 30,37----wind W. N. W.----fair. Barom. higheſt on the 9th, at 7, A. M.---therm. 27°---wind N. E.---cloudy.

A faint Aurora Borealis in the evening of the 2d---wind W. N. W.—and of the 27th---wind W.---fair for ſeveral days after them.

Diſeaſes in *Ipſwich*; coughs, bilious cholics, rheumatiſms —Healthy: In *Salem*; mild, continued and rheumatic fevers, bad coughs: In *Beverly*; inflammations of the eyes, tumors.

MARCH.

	Therm.			Barom.			
	A. M.	Noon.	P. M.	A. M.	Noon.	P. M.	
Higheſt,	50	56	55	30,73	30,41	30,53	Rain.
Loweſt,	16	24	21	29,30	29,30	29,28	Inch.
Mean ſtat.	33	43	40	30,12	30,02	30,05	1,733

Several ſmall ſnows, which ſoon melted; the air mild. Predominant winds from S. S. W. to N. W. The ground bare the greater part of the month, and very little froze. Six days of falling weather.

Greateſt deg. of heat on the 29th, at 1, P. M.---barom. 29, 72---wind S. E.---miſty. Greateſt deg. of cold on the 11th, at 7, A. M.----barom. 30, 50----wind W. N. W.----fair. Barom. higheſt on the 13th, at 7, A. M.---therm. 25°---wind N. N. W.---fair: loweſt on the 8th, at 11, P. M.---therm. 43°---wind very high at N.N.W.---fair.

A ſmall Aurora Borealis in the evenings of the 2d and 26th ---wind W.N.W.—the following days fair. In the evening of the 29th, the heavens were illuminated with a very bright and ſingular northern light. At 8^h 4′, when I firſt ſaw it, the northern heavens, as far as E. N. E. and W. S. W. were interſperſed with numerous Auroral clouds, and very bright ſpots, ſomewhat reſembling lighted torches. From the luminous ſpots converging corruſcations ſhot up, with a quick and tremulous motion, towards the zenith. The luminous clouds

were

were continually changing their form and ſituation, moving with a waving or flaſhing motion. At the ſame time, there was a bright glade or zone of light, compoſed of very fine ſtriæ, S. of the zenith; which extended acroſs the hemiſphere, in the S. E. and S. W. points, within 25° of the horizon. The ſouthern limb of the zone extended almoſt as far as the cloudy ſtar in *Cancer*, which was nearly on the meridian. At 8h. 15′, the ſtriæ in the zone, and ſtriated corruſcations from every other direction, approached towards a common center in the neck of *Leo major*, and formed a kind of vortex, which ſoon became two ſegments of a circle, and then changed into detached, flaſhing clouds. At 50′ after 8h., a very extenſive and denſe Auroral cloud was formed in the W. and N. W. with numerous ſtriæ curiouſly turned around its heads and indentations. At half after 9h., corruſcations from the N. extended beyond the zenith. At 10h., the light appeared only in the N. and greatly diminiſhed. There appeared to be an extremely rare fluid almoſt continually flaſhing beneath the ſtriated vapour, in various directions. The wind at W. and very ſmall till 10h., when it breezed up freſh at N. W. At 10h., therm. 53°, barom. 29, 72. Five preceding and ſeven following days fair.* Faint

 northern

* By a letter from the Reverend Dr. *Stiles*, Preſident of *Yale-College*, which I received ſoon after, it appears, that the extent of this northern light near the zenith, and the meeting of the corruſcations, were obſerved at *New-Haven*, (computed diſtance 180 miles, S. W.) to be as far S. and nearly in the ſame points in the heavens, as they were here. He ſays, that "At 8h 10′, the Auroral corruſcations "from the eaſtern, weſtern and northern heavens, concurred in a center 12° S. of "the zenith, in a line from the two ſtars (*Caſtor* and *Polux*) in the head of *Gemini* "to *Cor Leonis*. Had it been at the ſummit of the atmoſphere, it muſt have appeared 45° or 50° S. of the zenith, at the diſtance of fifty miles N. of *New-Haven*; "and yet the Reverend Mr. *Atwater*, of *Weſtford*, fifty miles N. obſerved it at 8h "10′, very nearly in the ſame place, and not S. of *Cor Leonis*.

northern lights in ſeveral of the preceding and following nights. Two bright parhelia on the 8th, in the morning.

Diſeaſes in *Ipſwich*; coughs, pulmonic complaints—Healthy: In *Salem*; inflammatory, pleuritic and rheumatic fevers, abſceſſes: In *Beverly*; pulmonic fevers, rheumatiſms, worms, &c.

APRIL.

	Therm.			Barom.			
	A.M.	Noon.	P.M.	A. M.	Noon.	P. M.	
Higheſt,	60	80	71	30,70	30,52	30,57	Rain.
Loweſt,	38	40	40	29,30	29,32	29,20	Inch.
Mean ſtat.	47	54	50	30,10	30,00	30,07	1,007

The weather warm and pleaſant. Winds principally from S. to W. N. W. The air frequently ſmoky. The 17th, exceſſive warm for this month; the therm. ranged at 82°, within doors, at 5, P. M. The ground very dry, which ſeems to have retarded vegetation. Five days on which rain fell.

Greateſt deg. of heat on the 17th, at 2, P. M.---barom. 29, 49---wind S.W.---fair. Greateſt deg. of cold on the 13th, at 7, A. M.--barom. 30,44---wind N. N. W.---fair. Barom. higheſt on the 24th, at 6, A. M.---therm. 48°---wind N.---cloudy: loweſt on the 12th, at 11, P. M.----therm. 42°---wind N. W.---rainy.

Early in the evening of the 7th, there appeared a bright Aurora Borealis, forming an arc about 20° above the horizon in the N. At 20′ after 8^h, the brightneſs greatly increaſed; and lucid ſpots, reſembling torches, at different heights above the arc, emitted numerous corruſcations. At 8^h 46′, a very bright Auroral zone was formed from E. to W. N. W. paſſing the meridian near the zenith. Its motion was viſible and uniform towards the S, preſerving its poſition as to the E. and W. points.

points. It appeared to be a luminous vapour of conſiderable denſity, ſomewhat broken near the meridian; but the edges were ſo well defined that its breadth was eaſily meaſured with a ſextant. The mean of the breadth, taken at ſeveral times and in different parts, was 16° 10′. In its progreſs, it paſſed above ſeveral ſmall clouds, which appeared very black, accurately defined, and far below the luminous vapour. After paſſing a little S. of *Procyon*, which it entirely obſcured, it became ſtationary at 36° 20′ S. of the zenith. In a few minutes the light grew faint, and, at 9^h. 2′, wholly diſappeared. Soon after, another ſimilar zone formed N. of the zenith, but much fainter, and not ſo broad as the former. It paſſed 5° 40′ S. of the zenith, and diſappeared. Before 9^h. the light in the N. was greatly diminiſhed, and appeared like a common Aurora. The wind was N. W. and very ſmall. At 9^h., therm. 49°----barom. 30,19. The preceding day, cloudy and rain---the third day after, rain and hail. There were alſo faint Auroras in the evenings of the 12th, 26th and 27th---the wind N. W.—rain on the day preceding that of the 12th, and rain, with thunder and lightning, that of the 26th—the ſucceeding days fair and cool.

Diſeaſes in *Ipſwich*; pleuritic fevers, worms, cholics, ophthalmias: In *Salem*; inflammatory and ſlow fevers, cholics, bad coughs: In *Beverly*; rheumatiſms, coughs,

MAY.

	Therm.			Barom.			
	A.M.	Noon.	P.M.	A. M.	Noon.	P. M.	
Higheſt,	67	78	69	30,59	30,32	30,42	Rain.
Loweſt,	45	50	49	29,42	29,33	29,42	Inch.
Mean ſtat.	51	61	57	30,02	29,88	29,96	4,005

Plentiful

Plentiful rain on the 8th, 9th and 10th, but the air very cool after it, especially in the night, which greatly retarded vegetation. Winds most prevalent from S. S. W. to W. N. W. Seed sewed last month lay long in the ground, and much of it perished. Eight days on which rain fell.

Greatest deg. of heat on the 18th, at 1, P. M.----barom. lowest---wind S.---fair. Greatest deg. of cold on the 5th, at 7, A. M.----barom. 29,79----wind N. W.----fair. Barom. highest on the 28th, at 6, A. M.---therm. 53°---wind N.W. ---fair.

Faint Aurora Borealis in the evenings of the 2d and 13th---wind N. W.---clouds and rain succeeded them. Severe thunder and lightning on the 23d, at 5, P. M.

Diseases in *Ipswich*; slow fevers, coughs, measles: In *Salem*; measles epidemic, inflammatory fevers, rheumatisms: In *Beverly*; anginas, tonsilaris, tumors.

JUNE.

	Therm.			Barom.			
	A.M.	Noon.	P.M.	A. M.	Noon.	P. M.	
Highest,	76	86	85	30, 42	30, 41	30, 41	Rain.
Lowest,	53	57	54	29, 45	29, 10	29, 38	Inch.
Mean stat,	66	75	69	29, 78	29, 58	29, 73	3,438

The temperature of the atmosphere, this month, exceedingly warm and moist, which produced a most rapid vegetation. Winds most prevalent from S. to W. Apple-trees less injured by canker-worms than the last year. Twelve rainy days.

Greatest deg. of heat on the 19th, at 2, P. M.---barom. 29, 17---wind S. W.---fair. Greatest deg. of cold on the 1st, at 6, A. M.---barom. highest---wind N.E.---cloudy. Barom. lowest on the 8th, at 2, P. M.---therm. 75°---wind very high at S. W.---fair.

Very

Very faint Aurora Borealis in the evenings of the 13th and 29th---wind W.---ſhowers on the following days. Frequent thunder and lightning.

Diſeaſes in *Ipſwich*; ſlow fevers, meaſles, eryſipelas, worms, pulmonary conſumptions: In *Salem*; meaſles, diſorders of the firſt paſſages, ſynochi, peripneumonies: In *Beverly*; meaſles epidemic.

JULY.

	Therm.			Barom.			
	A. M.	Noon.	P. M.	A. M.	Noon.	P. M.	
Higheſt,	81	89	85	30, 15	30, 07	30, 12	Rain.
Loweſt,	60	64	62	29, 27	28, 96	29, 26	Inch.
Mean ſtat.	68	73	65	29, 74	29, 58	29, 70	9,062

The weather very hot, with frequent heavy ſhowers of rain. Vegetation very luxuriant. Graſs, however, ſuffered ſo much by the drought and cold in the ſpring, that the crop of hay was indifferent. Grain of all kinds appeared very fine, but is greatly injured by mildew. Flax and garden eſculents exceeding good. Indian corn in a moſt flouriſhing ſtate. Garden and wild fruit, plenty. Predominant winds from S. W. to N. W. Twelve rainy days. Frequent thunder and lightning.

Greateſt deg. of heat on the 25th, at 2, P. M.----barom. loweſt---wind S. W.---ſhower approaching. Greateſt deg. of cold on the 1ſt, at 6, A.M.---barom. 29,78---wind N. E.---cloudy. Barom. higheſt on the 29th, at 6, A. M.----therm. 63°---wind N. W.---fair.

Diſeaſes in *Ipſwich*; meaſles, diarrhæas, ſlow fevers, pulmonic complaints: In *Salem*; dyſenteries, diarrhæas, ophthalmias, inflammatory fevers: In *Beverly*; meaſles epidemic.

AUGUST.

AUGUST.

	Therm. A.M.	Therm. Noon.	Therm. P.M.	Barom. A. M.	Barom. Noon.	Barom. P. M.	Rain. Inch.
Highest,	78	88	85	30, 20	30, 22	30, 25	Rain.
Lowest,	55	61	59	29, 38	29, 08	29, 07	Inch.
Mean stat.	66	72	68	29, 80	29, 37	29, 75	4,438

The air, by turns, very warm and very cool, for this season. On the morning of the 10th, considerable frost in low ground. At the eastward, it is said to have been so severe as to destroy most of the fields of Indian corn. On the 24th, the therm. in the shade abroad, ranged at 95°, at 2, P.M. Repeated large showers of rain. Prevailing winds between S. W. and N. W. Eleven days on which it rained.

Greatest deg. of heat on the 24th, at 1, P. M.----barom. lowest---wind S. S. W.---fair. Greatest deg. of cold on the 10th, at 6, A. M.---barom. 30, 20----wind N. W.----fair. Barom. highest on the 26th, at 10, P. M.----therm. 61°----wind N. E.---cloudy.

Small Aurora Borealis in the evening of the 16th---wind W.—and of the 19th---wind N. W. Rain and thunder the second day after the first---fair several days after the last. Thunder and lightning on the 3d, 8th, 13th and 18th.

Diseases in *Ipswich*; pulmonic and asthmatic disorders, worms—Very healthy: In *Salem*; slow and rheumatic fevers, synochi, diarrhæas, dysenteries, cholera morbus, cholics, vomiting and purging among children: In *Beverly*; measles, diarrhæas, worms.

SEPTEMBER.

	Therm. A. M.	Therm. Noon.	Therm. P.M.	Barom. A. M.	Barom. Noon.	Barom. P. M.	
Highest,	69	70	64	30, 38	30, 36	30, 40	Rain.
Lowest.	45	49	49	29, 60	29, 30	29, 47	Inch.
Mean stat.	57	62	57	29, 95	29, 80	29, 91	1,448

The

The weather variable. Predominant winds from S. W. to N. Froſt on the 4th and 23d, but only very tender plants injured. Garden eſculents in great plenty and perfection. Ten days on which rain fell.

Greateſt deg. of heat on the 14th, at 1, P. M.---barom. loweſt---wind S.W.---fair. Greateſt deg. of cold on the 23d at 7, A. M.---barom. 30, 38---wind N. W.---fair. Barom. higheſt on the 26th, at 9, P.M.---therm. 52°---windN.---fair.

Diſeaſes in *Ipſwich* ; worm caſes—Very healthy : In *Salem* ; ſynochi and ſlow fevers, abſceſſes, cynanche maligna, vomiting and purging among children : In *Beverly* ; meaſles, anginas, abſceſſes.

OCTOBER.

	Therm. A. M.	Therm. Noon.	Therm. P. M.	Barom. A. M.	Barom. Noon.	Barom. P. M.	
Higheſt,	55	61	67	30, 61	30, 52	30, 60	Rain.
Loweſt,	40	43	42	29, 39	29, 15	29, 38	Inch.
Mean ſtat.	49	53	51	30, 02	29, 91	29, 96	11, 607

High winds and heavy rains. A very ſevere ſtorm of rain on the 9th, and on the 18th and 19th, attended with exceſſive high winds at N. E. Towards the cloſe of the ſtorm on the 19th, conſiderable quantity of ſnow fell, but ſoon melted. In the morning of the 11th, heavy thunder, with hail and rain : alſo, ſevere thunder and lightning, with hail and rain, in the evening of the 31ſt----ſeveral buildings ſtruck, and creatures killed. Predominant winds from N. W. to N. E. Large crops of Indian corn. Apples, and other fall fruit, in greater plenty than the laſt year. No ſevere froſts. Graſs, and many kinds of vegetables retained their verdure through the month. Rained on fourteen days.

Greateſt deg. of heat on the 23d, at 1, P.M.---barom. loweſt ---wind S.S.W.---rainy. Greateſt deg. of cold on the 26th, at 7, A. M.---barom. higheſt---wind W. S. W.---fair.

Diseases in *Ipswich*; continued fevers, worm cases very rife: In *Salem*; slow and scarlet fevers, synochi, pleurisies—Sickly: In *Beverly*; bilious remitting fevers.

NOVEMBER.

	Therm.			Barom.			
	A.M.	Noon.	P.M.	A. M.	Noon.	P. M.	
Highest,	49	53	52	30, 80	30, 80	30, 84	Rain.
Lowest,	25	28	26	29, 16	29, 23	29, 37	Inch.
Mean stat.	36	40	39	30, 07	30, 07	30, 08	5,666

Very cold, blustering and stormy. Winds frequently very high, and most prevalent between W. and N. Ground froze hard on the 11th---snow fell on the 12th, and did not wholly go off during the month. Snowed, likewise, on the 28th and 29th---about four inches fell in the month. Nine days of falling weather.

Greatest deg. of heat on the 4th, at 1, P. M.---barom. 30, 03----wind W. S. W.----fair. Greatest deg. of cold on the 23d, at 8, A. M.---barom. 30, 56---wind W. N. W.---fair. Barom. highest on the 18th, at 11, P. M.---therm. 32°---wind W.---fair: lowest on the 28th, at 8, A. M.---therm. 38°---wind N. E.---snowed.

A small shock of an earthquake about 11 o'clock in the night of the 29th, but was felt by very few people in this town.

Diseases in *Ipswich*; continued fevers, worm cases, coughs: In *Salem*; low, depressed fevers, cynanche maligna: In *Beverly*; bilious remitting fevers.

DECEMBER.

	Therm.			Barom.			
	A. M.	Noon.	P. M.	A. M.	Noon.	P. M.	
Highest,	55	54	54	30, 72	30, 58	30, 63	Rain.
Lowest,	14	16	17	29, 18	29, 09	29, 30	Inch.
Mean stat.	34	37	36	30, 19	30, 03	30, 07	4,933

The

The former part of the month rather mild and pleasant, but the latter, blustering, stormy and cold. The ground mostly bare to the 18th, and then covered with snow to the end of the month. Predominant winds from W.N.W. to N.E. Seventeen days of falling weather. Snow fell fourteen inches deep during the month.

Greatest deg. of heat on the 12th, at 8, A. M.----barom. 29,84---wind S.W.---fair. Greatest deg. of cold on the 24th, at 8, A.M.---barom. 30,35---wind W.N.W.---fair. Barom. highest on the 15th, at 8, A.M.---therm. 30°---wind N.N.W. ---fair: lowest on the 1st, at 1, P. M.---therm. 41°---wind N. E.---rainy.

Diseases in *Ipswich*; putrid fevers, coughs, worm cases—Healthy: In *Salem*; febrile disorders frequent, as pleurisies, rheumatisms, catarrhal fevers, cynanche maligna, abscesses: In *Beverly*; hæmoptoes, slow fevers, coughs.

1783.	Thermometer. Greatest Height.	Least Height.	Mean Height.	Barometer. Greatest Height.	Least Height.	Mean Height.	Rain. Inches.
January,	46	7	31	30, 90	29, 41	30, 07	4,033
February,	53	1	36	30, 84	29, 64	30, 24	4,907
March,	56	16	39	30, 73	29, 28	30, 06	1,733
April,	80	38	50	30, 70	29, 20	30, 06	1,007
May,	78	45	56	30, 59	29, 33	29, 95	4,005
June,	86	53	70	30, 42	29, 10	29, 79	3,438
July,	89	60	69	30, 15	28, 96	29, 67	9,062
August,	88	55	69	30, 25	29, 07	29, 64	4,438
September,	70	45	59	30, 40	29, 30	29, 89	1,448
October,	67	40	51	30, 61	29, 15	29, 96	11,607
November,	53	25	38	30, 84	29, 16	30, 07	5,666
December,	55	14	36	30, 72	29, 09	30, 07	4,933
Whole Year,	89	1	50	30, 90	28, 96	29, 95	56,277

XVI. *An Account of ſeveral Strata of Earth and Shells on the Banks of* York-River, *in* Virginia; *of a ſubterraneous Paſſage, and the ſudden Deſcent of a very large Current of Water from a Mountain, near* Carliſle; *of a remarkably large Spring near* Reading, *in* Pennſylvania; *and alſo of ſeveral remarkable Springs in the States of* Pennſylvania *and* Virginia. *In a Letter from the Hon.* BENJAMIN LINCOLN, *Eſq; F. A. A. to the Rev.* JOSEPH WILLARD, *V. Preſ. A. A. and Preſident of the Univerſity at* Cambridge.

THAT this earth, ſince its formation, has met with great changes, and that the ſhores, now covered with the talleſt cedars and moſt luxuriant plants, were once waſhed by the ocean, none can deny. The land between *James-river* and *York-river,* in *Virginia,* is very level; its ſurface being about forty feet above high-water mark. It appears to have arrived to its preſent height at different periods, far diſtant each from the other, by means of the ocean: for, near *York-town,* where the banks are perpendicular, you firſt ſee a ſtratum of earth, about five feet high, intermixed with ſmall ſhells, which has the appearance of a mixture of clay and ſand. On that lies, horizontally, a ſtratum of white ſhells, the cockle, the clam, and others, an inch or two thick; then a body of earth, ſimilar to that firſt mentioned, eighteen inches thick: and on that lies another thin body of ſmall ſhells, then a third body of earth, about the ſame thickneſs as the laſt; and on that lies another body of white ſhells, of various kinds, about three feet thick, with very little ſand, or earth, mixed with them. On theſe lies a body of oyſter-ſhells, about ſix feet thick; then a body of earth to the ſurface. The oyſter-ſhells are ſo united by a very

ſtrong cement, that they fall only when undermined, and then in large bodies, from one to twenty tons weight. They have the appearance of large rocks on the ſhores, and are waſted by the frequent waſhing of the ſea. All theſe different ſtrata ſeem to be perfectly horizontal.

After riding about ſeven miles from *York-town*, near the center between the two rivers, I diſcovered, at a place from which a large body of earth had been removed to a mill-dam, nearly the ſame appearance as in the bank firſt mentioned.

What they call their ſtone, with which they build in *York-town*, is nothing more than ſhells, united by a ſtrong cement, which ſeems to be petrified in a degree, but is apparently affected by the weather.

ON the 2d of Auguſt, being at *Carliſle*, in the ſtate of *Pennſylvania*, I went to view a ſubterraneous paſſage, which had its entrance near a river into a rock. I followed it about two hundred and fifty feet: to this diſtance it was, in general, from ſix to ſeven feet high, and about the ſame in width. At the end of two hundred and fifty feet it divided into three branches.—As they were ſmaller, and more difficult to follow, and finding myſelf exceedingly chilled, (which coſt me one of the ſickeſt nights I ever ſuffered) I gave up the purſuit, though I had proceeded but about half the diſtance, as I was informed by Col. *Butler*, who had been near the end. It appeared to me that it was a water-courſe, as the rocks were worn ſmooth, and indented in the manner they uſually are by a long running of water over them. The appearance over head was curious; ſome parts were ſmooth like the ſides; other parts repreſented various figures, formed by the water which had penetrated through the pores

pores of the rock, and was now petrified and petrifying on its surface. The bottom was apparently earth and small stones.

About three years since, the people in the vicinity of this town, who lived near the mountain which is about ten miles from the village, were alarmed by a current of water overflowing the banks of the river. The cause they could not investigate, as there had been, the night before, but a small rain: however, they soon found the first effects of the water appeared within about twenty feet of the top of the mountain. Whether it burst forth from the mountain, or was a column of water from the clouds, has not yet been ascertained. The course in which it ran down the mountain was dry the next morning. It was confined to the width of twenty feet, perhaps less. It appeared to be about thirty feet deep, as could be discovered by its effects on those trees which were not carried away by the water. It cut a passage in the side of the mountain, of about seven or eight feet wide, and near that depth. The traces of it are seen from the town, though, as I said before, it is ten miles distant. One rock, of a very considerable weight, was thrown into the crotch of a tree, twelve feet from the ground, in which it remained for some time. When the water came into the valley, its impetuosity was so great that it was not immediately diverted, but reached a small rising ground, through which it cut a passage; then followed the valley, and so on to the river, which was at some considerable distance. In its course, it carried off all the fences, and came upon the floors of some of the houses. I have had some conversation with Mr. *Rittenhouse* on the subject, who has been twice to see the effects of the water. It is his opinion, that it was not a column of water which bursted forth from the mountain, as it was near the top of one of the highest.

On

On my return to *Philadelphia*, in the neighbourhood of *Reading*, I came to the greateſt ſpring of water I had ever ſeen.—It is about fourteen feet deep, and about one hundred feet ſquare. A full mill-ſtream iſſues from it. The water is clear and full of fiſhes. To account for this body of water, was my enquiry. I ſoon found, that it was probably the riſing and burſting forth of a very conſiderable river, which ſunk into the ground and totally diſappeared, one mile and an half or two miles diſtant from this place.

In the northern parts of *Pennſylvania*, there is a creek, called *Oil-Creek*, which empties itſelf into the *Alleghana-river*, iſſuing from a ſpring, on the top of which floates an oil, ſimilar to what is called *Barbadoes* tar, and from which may be collected, by one man, ſeveral gallons in a day. The troops, in marching that way, halted at the ſpring, collected the oil, and bathed their joints with it. This gave them great relief, and freed them immediately from the rheumatic complaints with which many of them were affected. The troops drank freely of the waters :—they operated as a gentle purge.

There is another ſpring in the weſtern parts of *Virginia*, as extraordinary in its kind as the one juſt-mentioned, called the *Burning-Spring*. It was known a long time to the hunters. They frequently encamped by it for the ſake of obtaining good water. Some of them arrived late one night, and, after making a fire, they took a brand to light them to the ſpring. On their coming to it, ſome fire dropped from the brand, and, in an inſtant the water was in a flame, and ſo continued, over which they could roaſt their meat as ſoon as by the greateſt fire. It was left in this ſituation, and continued burning for three months without intermiſſion. The fire was extinguiſhed by

excluding

excluding the air from it, or ſmothering it. The water taken from it into a veſſel will not burn. This ſhews, that the fire is occaſioned by nothing more than a vapour that aſcends from the waters.

There are two ſprings high up on the *Powtomack* ; one of which has about the ſame degree of heat as blood running from the veins. It is much frequented by people who have loſt their health. The waters are drank with freedom, and alſo ſerve as a hot bath, by which much good has been experienced. The other ſpring, iſſuing from the ſame mountain, a little further up, is as remarkable for its coldneſs, as the other for its heat, and differs from common ſprings in as many degrees.

Theſe accounts I have from the beſt authority. General *Waſhington,* from whom I had my information, as well as from others, owns the land around the *Burning-Spring,* which he bought for the ſake of it.

The accounts of the other ſprings I received from a gentleman of undoubted veracity, and of great obſervation, who lately viſited them. He commanded the troops who experienced the benefit of the *Oil-Spring.* He mentioned to me another ſpring in the ſouth-weſterly part of *Virginia,* which he had not ſeen, but of which he had received a particular account from gentlemen of character. It is called the *Sweet-Spring,* from the ſweetneſs of the waters, which have been found efficacious in many diſorders, and have given relief when every other attempt has proved ineffectual.

To theſe I may add the great number of ſalt ſprings in *America,* eſpecially on the *Ohio,* and the rivers which empty into it. There is one ſpring on the *Miſſiſſippi,* from which ſalt is made ſufficient to ſupply the whole *Ilinois* country with that article.

XVII. *An Account of large Quantities of a fossil Substance, containing Vitriol and Sulphur, found at* Lebanon, *in the State of* New-Hampshire, *accompanying a Specimen. In a Letter from the Reverend* JEREMY BELKNAP, *F. A. A. and Member of the Philosophical Society at* Philadelphia, *to* SAMUEL WILLIAMS, *L. L. D. F. A. A. and Hollis Professor of Mathematics and Philosophy in the University at* Cambridge.

Dover, September 28, 1780.

SIR,

HEREWITH I send you a specimen of a stone, which, by the efflorescence upon it, you will see to be rich in vitriol, and by the smell, you will perceive to contain a great proportion of sulphur. It was taken out of the cellar-wall of an house at *Lebanon,* in the county of *York,* where it had been placed for about fifteen years. The same kind of stone is found in vast quantities, for a considerable distance round the spot. The neighbouring people use it for dyes, and for blacking leather, with as much success as the best imported copperas. As there is plenty of wood and water there, I think a manufactory might be established to great advantage. You will judge whether this hint is worth communicating to your newly established Society.

I am, Sir,
Your friend and humble servant,
JEREMY BELKNAP.

XVIII. *An Account of yellow and red Pigment, found at* Norton, *with the Process for preparing the Yellow for Use; accompanied with Specimens. In a Letter from the Reverend* Samuel Deane, *F. A. A. to Mr.* Caleb Gannett, *Rec. Sec. A. A.*

Falmouth, May 30, 1782.

SIR,

IN several places in *Norton*, in the county of *Bristol*, in the *Massachusetts*, has been found a fossil, near the surface of the earth, mixed with sand and small pieces of iron ore, from which is extracted two kinds of substances useful in painting, viz. yellow and red.

To make the yellow, the process is as follows: They mount a tub, or vat, on blocks two feet high, and put into it one third part as much of the earth as will fill it: then fill it up, almost to the brim, with water. After this, with hoes, they bruise it, and stir it about till it is dissolved and well mixed with the water. The sand, gravel and iron ore, in about the space of a minute, will sink to the bottom; at which time they draw off the water, with the pigment floating in it, letting it fall through a common bread-sieve, into a vat, or tub, standing on the ground. When the paint is all sunk to the bottom, the water is taken off through holes in the sides, and the paint dried well in the open air and sunshine, on a floor made tight and surrounded with a border, to prevent its running off. Being thoroughly dried, it is fit for grinding by the painter, making a greenish yellow colour. And I am told, a little black paint mixed with it, renders it a beautiful olive colour.

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The yellow paint, being dried as above, and then brought to a red heat, in a kettle over a hot fire, becomes a red paint resembling *Spanish*-brown, but of a finer and brighter colour. It is used by painters instead of *Spanish*-brown. They use it for out-door work; and time will soon discover whether it will not be equally durable. The manufacturers sell it for about three pence a pound, which is cheap; and it bids fair to be of great service to the public.

In the same town is found a white fossil, out of which is made a paint resembling *Spanish*-white, or whiting. But concerning this I have not been able to gain much information.

I have left samples of the yellow and red with the Keeper of the Cabinet: and if you think fit, you may communicate this to the Academy at their next meeting.

I am, Sir,

Your most humble servant,

SAMUEL DEANE.

Mr. *Gannett*.

P. S. Since writing the above I find, that this paint has stood the weather well, in several instances, for three or four years; and bids fair to prove durable: and that the *red*, in its present state, is sold at fifteen shillings per hundred weight; which is cheaper than can be obtained from *Europe*.

XIX. *An Account of an Oil-Stone found at* Salisbury. *In a Letter from the Reverend* SAMUEL WEBSTER, *to Mr.* CALEB GANNETT, *Rec. Sec. A. A.*

Salisbury, January 24, 1783.

SIR,

I HAVE found what the goldsmiths use, and call an oil-stone, equal, if not superior, to those imported from *Turkey*.—But as it was so small as only to make two, one for each of my sons, who are goldsmiths, it is not in my power to send you a sample, It is extremely hard, and somewhat brittle; so that I easily broke it into two pieces. When it is ground it is exceedingly smooth, and serves to smooth their engraving tools. I found it in my field by accident, and was excited, from its uncommon appearance, to take it up, not knowing, at that time, what it was. It is somewhat curdled with light and dark brown, or, when ground, it approaches to a light chocolate colour, somewhat clouded. Before it was ground some compared it to *Castile* soap. I have made considerable search for more, but without success. I doubt not, however, that we have them in the country, perhaps in plenty. I found this in moist ground. These stones are necessary for all those who make use of engraving tools, and are now very scarce and dear.

I send you a piece of marble found near the mouth of *St. John's-River*, in *Nova-Scotia*. It is found of various colours,—white, bluish and veined. I also send you a sample of salt, made from a salt-spring in the *Seneca* country, on *Mohawk-River*: and a sample of cloth, coloured black with sumach-berries alone, without copperas. I am, &c.

SAMUEL WEBSTER.

Mr. *Caleb Gannett*.

XX. *Observations on the Culture of* Smyrna *Wheat. In a Letter from* BENJAMIN GALE, *F. A. A. Member of the Philosophical Society at* Philadelphia, *and Fellow of the Royal Society in* London, *to his Excellency* JAMES BOWDOIN, *L. L. D. Pres. A. A.*

Killingsworth, 25th August, 1783.

SIR,

I SEND you a few heads of the true *Smyrna* wheat, a species of that grain, which I apprehend is the best adapted for the horse-keeping husbandry, believing it will answer for tillage equal to our Indian corn. Dr. *Elliot* made various attempts to procure it, without succeeding. This happens to be much blasted, owing partly to the season, and in part to being late sowed, viz. late in September, after the rains came on, at the end of a long drought; and being sowed in my garden, contiguous to some barberry-bushes; to all which, *by leaving open my gate*, my sheep got in during the winter, the ground not being covered with snow, ate it off even with the ground.—But am of the opinion, from the strength of the stalk, a specimen of which I also send you, a part of the second joint, divested of the leaf which covers it, and also the upper joint which supports the ear, which is solid, it appears better able to support the heads, and will not be subject to a rupture of the vessels, which is often the case in a blasting season; and from its being about ten days earlier than common wheat, puts it still further more out of the danger of the blast. Those ears which have but one head, I apprehend, from the similarity of the leaf and stalk, are of the same species with those which have more heads: one of which has four ears of a side, springing out of the main

ear,

ear, which I apprehend owing to having more room, more culture, and, perhaps, the earth, contiguous to the roots, richer. The method of culture, if you are not acquainted with *Tull's* tillage, is, to make a ſmall ridge, in form of a bed for peas, on which make two rows, at about ten inches diſtant, and the ſeeds planted at about half an inch diſtance in the rows, which muſt be hoed, and kept clean from graſs or weeds. Should you not have a curioſity yourſelf, in this way, you may perhaps oblige ſome of your friends, who may be in the farming way. It would be well to put the ſeed into the ground ſoon.

I have the honour to be, Sir, &c.

BENJAMIN GALE.

Honourable *James Bowdoin*, Eſquire.

XXI. *An Account of an Experiment for raising Indian Corn in poor Land. In a Letter from* JOSEPH GREENLEAF, *Esq; to the Reverend* JOHN CLARK, *F. A. A.*

Boston, May 26, 1785.

SIR,

WHILE I resided in the country, I found it was the opinion of the farmers, that whoever raised Indian corn paid more for it, in labour, than it was worth: that the land must be strong, highly manured, well plowed and hoed, or it would not produce a crop half equal in value to the expence bestowed upon it: that the land, in a very few years, would be worn out, and must lie useless a number of years afterwards to recover its fertility.

To convince them of their error, I purchased, of one of my neighbours, a piece of land which he affirmed was worn out, and unfit to produce any crop of any kind. The land was dry, and not a stone in it; the soil was very light and shallow, inclining to sand. The ground was over-run with briars and weeds, called *St. John's*-wort, with here and there a spire of coarse wild grass.

Upon this piece of ground I made the following experiment. In the first place I procured a plough, made under my own direction, with a sharp coulter, and a share about a fourth part of the size and weight of common plough-shares; and with a furrow-board, on a new construction, that followed the coulter edge-wise, turning the furrow over in rather a spiral form. With this plough, which required only the strength of a single horse, a furrow was ploughed through the whole length of my field,

and

and, returning with the plough on the ſide next to which the furrow was turned, threw up another furrow againſt the firſt. At four feet diſtance from this another double furrow was ploug-ed, in the ſame manner; and ſo on, leaving a ſpace of four feet between the double furrows, through the whole field. Upon theſe double furrows potatoes were planted, leaving the ſpace of four feet between each hill. This field contained two acres and an half, and was about forty rods in length. It was ploughed and planted, in one day, with one horſe and two boys. When the potatoes came up and wanted tending, the ſame boys, with the ſame horſe and plough, turned another furrow of the unploughed ground towards the potatoes, on each ſide, and dreſſed them with their hoes: this they alſo performed in one day. At half-hilling, it was repeated, and the whole field be-came ploughed. At hilling, the field was croſs-ploughed, the earth thrown towards the crop each way, and dreſſed with the hoe. By this mode, two acres and an half was compleatly tilled in four days, with the labour of only two boys and one horſe; which, in the common way of managing ground, would have required ten days labour of one man, one boy, and two horſes.

The next ſpring I ploughed, between every two rows of the old potatoe-hills, two furrows, which were thrown one againſt the other, and planted my corn upon them, without any manure. The ploughing and planting was performed by the ſame horſe, plough and boys, in one day. My corn was huſbanded in the ſame manner my potatoes were the year before. A field on the other ſide of the fence, much of the deſcription and ſize of mine, was two days and an half in ploughing and planting, with one man, a boy, two horſes, and a common plough. This field,

was

was planted on the ſame day with mine, and was well dunged. My corn made its appearance about two days before my neighbour's, ripened more than a fortnight earlier, and I had the largeſt crop.

I continued to plant corn in the ſame land, between the old hills as before-mentioned, for three years ſucceſſively, without carrying on any manure,—the crops increaſing about two buſhels every year. My removing to *Boſton* prevented my repeating the experiment. You will join with me in lamenting the loſs to the public of thouſands of acres of land that lie uſeleſs in this commonwealth, from a miſtaken notion that ſuch land is worn out, and not capable of producing a crop ſufficient to pay even for the ſeed that is planted.

I am, &c.

JOSEPH GREENLEAF.

The Reverend *John Clarke.*

XXII. *An Account of a singular Apple-Tree, producing Fruit of opposite Qualities; a Part of the same Apple being frequently sour, and the other sweet. In a Letter from the Reverend* PETER WHITNEY, *to the Reverend* JOSEPH WILLARD, *V. Pres. A. A. and President of the University in* Cambridge.

Northborough, July 15, 1782.

REVEREND SIR,

THERE is now growing in an orchard, lately belonging to my honoured father, the Reverend *Aaron Whitney*, of *Petersham*, deceased, an apple-tree, very singular with respect to its fruit. The apples are fair, and, when fully ripe, of a yellow colour, but, evidently, of different tastes—sour and sweet. The part which is sour is not very tart, nor the other very sweet. Two apples growing side by side, on the same limb, will be often of these different tastes, the one all sour, and the other all sweet. And, which is more remarkable, the same apple will frequently be sour on one side, end, or part, and the other sweet, and that not in any order or uniformity; nor is there any difference in the appearance of the one part from the other. And as to the quantity, some have more of the acid and less of the sweet, and so *vice versa*. Neither are the apples so different in their tastes, peculiar to any particular branches, but are found, promiscuously, on every branch of the tree. The tree stands almost in the midst of a large orchard, in a rich and strong soil, and was transplanted there about forty years ago. There is no appearance of the trunk or any of the branches having been ingrafted or inoculated. It was a number of years, after it had born fruit, before these different

ferent taſtes were noticed ; but ſince they were firſt diſcovered, which is about twenty years, there has been conſtantly the ſame variety in the apples.

For the truth of what I have aſſerted, I can appeal to many perſons of diſtinction, and of nice taſtes, who have travelled a great diſtance to view the tree, and taſte the fruit ; but to inveſtigate the cauſe of an effect ſo much out of the common courſe of nature, muſt, I think, be attended with difficulty. The only ſolution I can conceive is, that the *corcula*, or hearts of two ſeeds, the one from a ſour, the other from a ſweet apple, might ſo incorporate, in the ground, as to produce but one plant : or that farina, from bloſſoms of thoſe oppoſite qualities, might paſs into, and impregnate the ſame ſeed. If you ſhould think the account I have given you, of this ſingular apple-tree, will be acceptable to the *American* Academy, pleaſe to communicate it.

I am, &c.

PETER WHITNEY.

Reverend Preſident Willard.

XXIII. *A Letter from the Honourable* BENJAMIN LINCOLN, *Esq; F. A. A. to the Honourable* JAMES WARREN, *Esq; F. A. A. relating to the ingrafting of Fruit-Trees, and the Growth of Vegetables; inclosing the Observations of his Friend on the Growth of Trees downward after the first Year.*

Hingham, November 3, 1780.

MY DEAR SIR,

I TAKE this early opportunity, agreeable to my promise, to enclose you the sentiments of my friend on grafting, the growth of plants, trees, &c. These were given on a conversation which arose on my mentioning, that I had observed, for a number of years, an apple-tree in my orchard, the natural fruit of which was early, having been grafted with a winter cyon, producing fruit very like in appearance to the fruit produced by the tree whence the cyon was taken, but destitute of those qualities inherent in that fruit, and necessary to its keeping through the winter. This led me to call in question the propriety of grafting winter fruit on a summer stock, and to enquire, whether the stock through which, I supposed, the food passed to the cyon, and by which it was fitted properly to nourish the helpless and newly adopted branch, would not rather assimulate *that*, than that the cyon could, thus fed, retain all the qualities of its parent stock.

I am sensible that there are objections to this new system; and, perhaps, difficulties may be raised to it, which cannot be obviated.—But, as this may arise either from the erroneousness of the doctrine itself, or from the want of knowledge in the principles of vegetation, I think it should not be adopted or rejected

rejected without the fulleſt enquiry; and eſpecially, ſince a knowledge of the laws of vegetation is one of the moſt intereſting matters which can be the ſubject of diſcuſſion: for on vegetation depends our being; and in the ſame proportion as we obtain a knowledge thereof, and practiſe on that knowledge, in that proportion is our well-being promoted. That cultivation promotes vegetation, I think, none will deny: for ſurely the earth, ſpontaneouſly, gives us but a bare ſubſiſtence. The reaſons aſſigned, why the earth did not more early bear fruit, were, becauſe *there was no rain on the earth*, and becauſe *there was no man to till the ground*.—The neceſſity of which ſeems to have produced one of the firſt decrees from heaven to man, even while he was in *Eden*, ſurrounded with all the bleſſings thereof, that he ſhould dreſs the garden. Whether tilling and dreſſing the earth ſo prepares its parts that they became proper food for the plant, and thereby promote vegetation;—whether, by tilling and dreſſing, the land is fitted properly to receive the rays of the ſun, and to receive and retain a ſuitable quantity of water, with which food for the plant is ſuppoſed, by ſome, to fall;—or whether, by tilling and dreſſing, the land does really partake of more particles neceſſary to vegetation, and ſo attracts like particles floating in the air, as ſimilar bodies attract each other, and ſo light on, and feed the plant in their fall, or do reſt on the earth, are abſorbed by the roots, and thence conveyed thro' the whole plant, are queſtions which can, I think, be determined with more eaſe and greater certainty when the principles of vegetation are fully aſcertained.

Pleaſe to favour me with the reſult of your enquiries on theſe matters, and it will much oblige him who has the honour to be, &c. B. LINCOLN.

Hon. Gen. *Warren*.

THE

THE idea has universally obtained, that *Trees grow from the root upwards*. But perhaps it may appear probable, from the following considerations, that *Trees, from the first year, grow from the top downwards*.

The growth of annual plants seems to be the mere expanding of the parts contained in the seed, or bulb, which is a more perfect and full grown seed, differing but little from what is commonly called seed. Of this, the bulb of a tulip is the best example, as the parts are visible without the help of glasses. Upon removing the several coats of the bulb, each of which are the support of a leaf, in the center of it, a large flower, near half an inch in length, will be found, and, in thickness, as large as a rye-straw; in which the petals, stile, filaments and buttons are fully formed, and perfect in every respect but size and colour. The lower leaf of the plant, which, within the bulb, covers all the rest, swells and expands first: then the next above swells and expands; and so on, until the whole are expanded: after which, the stalk rises, the flower swells and opens, and its beautiful colours are separated and exhibited to the eye. In this growth the bulb is entirely wasted, except only the fine skin that covered each squamina, which remains much thinner than white paper. In the center of the bulb, below the leaves and adhering to the stalk, may be seen a very small bulb, much less than the seeds of the plant. This bulb is, however, increased with the growth of the leaves, until it becomes of the size of the parent bulb: and when the stalk, the leaves and fibrous roots decay and dry up, this new bulb remains, in the place of the old one, capable of a like growth the next year.

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The firſt year's growth of a tree, like that of plants, is the mere expanſion of the parts contained within the ſeed, ſo far as thoſe parts are fitted for growth; and being expanded, the wood formed has no further growth, in any direction, but remains of the ſame ſize until it decays. Each leaf which grows on the firſt year's ſhoot, as well as thoſe of ſucceeding years, has annexed to it, immediately above its ſtem, an embryo bud, which is nouriſhed and fitted to grow the following year, and to become a branch of the future tree. The leaf having performed its maternal duty, falls to the ground, and manures the tree from whence it fell.

The wood of theſe ſaplings of a year, is uniformly of one texture; but the wood of the next year is ſeparated from it by a circular line, which remains as long as the wood laſts. Every ſucceeding year is diſtinguiſhed in the ſame manner; ſo that by cutting the tree on one ſide, from the circumference to the center, and counting thoſe circles, you may aſcertain its age.——And one of the main queſtions, ariſing in the conſideration of this ſubject, is, how are theſe annual additional circles of wood formed? Are they formed by the filling and expanding of fibres, which, too ſmall for the obſervation of our ſenſes, lie between the bark and the tree? or are they new fibres ſhooting either from below or from above? It appears, by examining the wounds of trees, that the wood being once ſeparated never heals up and grows together.—The new wood grows over, and covers the wound; but the ſeparated veſſels never unite again: therefore, if the edge of a knife be paſſed tranſverſely thro' the bark half round a ſapling, and thoſe ſuppoſed extreme fine veſſels were cut off, that ſide of the tree ought to ceaſe growing, and the buds above it periſh. But the fact is otherwiſe: for, cover

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the wound so as the air may be prevented from carrying off the moisture, which, when uncovered, flows from the wound, the buds above will grow nearly as well as if the wound was not made. To suppose that new vessels, formed at the root, ascend, and seeking the buds, by passing round the incision, immediately find them, is too ludicrous an objection to be seriously noticed. Let us, then, consider the buds which are formed in the bosom of every leaf.

One of those buds, rended from its parent plant, and inserted in the bark of another tree of the same genius, will grow as well as if it had been continued where nature placed it, and become a compleat tree. Here, at least, there is a certainty, that there are no fibres calculated to support it, yet it will grow; and the whole tree, above the insertion in the stock, thus springing from a foster-bud, is exactly of the same nature in all respects, and produces the same fruit as the tree from which the bud was taken. This is the wonderful circumstance, which, though often attempted, has never been clearly accounted for. We shall proceed to enquire, then, how buds inserted in foreign stocks attain their growth.

When a bud is bro't into contact with the stock, and the bark of the stock passed round and upon the bark laid in with the bud, the sap very quickly forms a gum, which glues them together, and stops the mouths of those vessels which had been torn by separating the bark and bud from the parent tree. Whoever examines the fact, must be convinced, that the bud, thus laid in, never has any further adherence to the stock; but remains, during the life of it, liable to be separated from it by dissolving that gum; and, from this circumstance, the size and shape of the wood, or bark, laid in with the bud, may be plainly discovered

vered many years after its insertion. Here the communication between the stock and the bud is destroyed: for, if the sap penetrated this gum, it would dissolve it, and the bud would fall off; and there can certainly no fibres be sent from the root to feed a bud, which nature had not placed there. Nothing but experiment could induce a belief, that a bud, thus situated, would grow, become a tree, blossom and bear fruit. Let us see how buds grow in the situation assigned them by nature.

The largeness of the bud, and the freedom with which it shoots, renders the peach-tree a proper subject of this enquiry. Early in the spring, when the bud first begins to swell, we shall find one or more fibres shooting from it downward. These fibres are so large, below the bud, as apparently to swell the bark, and on removing the bark the fibres may be plainly seen by the naked eye. Whoever carefully examines this fact, will scarcely doubt that this is really the manner in which buds begin to grow. Inoculations having the same power of sending out fibres from themselves as buds, in their natural situations, need no nourishment from the stock on which they are fixed; but it becomes the question, from whence is their nourishment derived?

A curious yellow carnation, presented to a gentleman at *Lancaster*, in the year 1778, being transplanted very early in the spring, and the weather proving very cold, he was obliged to take it into the house, and keep it in a room where fire was kept. Notwithstanding his utmost care in keeping the earth well watered, the plant declined, the leaves became soft, and rested on the earth, and the plant shewed every sympton of approaching death. In this state, having bended twigs over the pot, he wet a thick tow-cloth and threw over the plant, which

formed a moist atmosphere round it. In a few hours the leaves became erect, and elastic, and within three days the whole plant assumed the aspect of perfect health. The roots had a full supply of moisture, but it did not grow; the leaves were supplied, and the plant instantly flourished.

The first appearance of vegetation among trees here, is the flowing of the sap in the sugar maple. This begins with the frosty mornings in the month of February. These hoar frosts never apppear but when the air is moist; and it is invariably certain that the sap ceases to flow when the wind is at north-west and the air dry, be the state of the earth as to moisture or frost as it may. From hence it appears, that the sap is extracted from the air even before the leaf is expanded, and not from the earth, as is generally supposed.

The next appearance of vegetation, is the swelling of the bud in the scarlet maple; and in this, as in all other trees, it is to my purpose to observe, that the uppermost buds always swell first, and its beautiful blossoms are seen earliest to unfold on the topmost boughs. This cannot depend on a sap derived from the root; for, in that case, the lowermost should have unfolded first.

The husbandmen of *New-Jersey*, upon those lands which do not produce oak-timber sufficient for fencing, shave the bark from the pine trees in the latter part of winter, and in the spring, the turpentine running down over that part of the tree which has been barked, fills the pores, and preserving it against the water, renders the pine a very durable post for fencing. The turpentine, as I conceive, being collected from the air, descends from the top of the tree. This practice, lately introduced, deserves attention, not only as an argument in this question, but

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as an important leſſon of inſtruction to thoſe who live on pine lands.

The experiments made on fruit-trees, by extending their branches into green-houſes while the roots remain in the ground, need not be repeated. They are better known than underſtood ; and can only be accounted for by ſuppoſing that their nouriſhment is derived from the air. Of this the following experiment may be a proof.

A branch of the maple being ſeparated from the tree, and the lower end ſealed, placed in any part of the tree, will bloom as ſoon as any of the adjoining branches not ſeparated from the tree will do. The buds of trees, deriving their nouriſhment from the air, ſend down their fibres between the bark of the tree and the former year's growth of wood, and lay an additional wood over the former growth. It is upon this principle alone, that the growth of inoculations can be accounted for ; and it is clear and plain, that every bud has its own pith, perfectly diſtinct from the tree it is attached to, and has alſo in itſelf every other part of a tree.

From a due conſideration of what has been ſaid, it will appear, that the growth of annual plants is the expanding of the parts contained within their ſeeds as bulbs, and a production of other ſeeds and bulbs, perfectly diſtinct and unconnected with the former ; but that the growth of trees after the firſt year is the expanding of buds, adhering to the former growth, and the fitting of other buds for future growth attached to the tree, as well as forming of ſeeds, as annual plants do.

XXIV. *An Account of some of the vegetable Productions, naturally growing in this Part of* America, *botanically arranged. By the Rev.* MANASSEH CUTLER, *F. A. A. and M. S. and Member of the Philosophical Society at* Philadelphia.

IN an infant country, where nature has been liberal in her productions, and internal resources are greatly wanted, few objects can be of greater importance than natural history. Yet, unhappily, there is no branch of useful knowledge we have so little cultivated. The cultivation of this branch of science will open to our view the treasures we possess unenjoyed; and must eventually tend to the security and welfare of our citizens, the extension of their commerce, and the improvement of those arts which adorn and embellish life.

The little progress we have made in exploring the fossil kingdom, is sufficient to convince us, that the bowels of the country are well stored with minerals and other useful fossils; which are capable of being improved, not only for the benefit of individuals, but as national advantages.

We have, perhaps, as great a variety of indigenous plants, as any country produces, in a similar climate. But a great part of them have never been so far noticed as to receive even a trivial name. *Canada* and the southern states, beside the attention paid to their productions by some of their own inhabitants, have been visited by eminent botanists from *Europe*. But a great part of that extensive tract of country, which lies between them, including several degrees of latitude, and exceedingly diversified in its surface and soil, seems still to remain unexplored.

The almost total neglect of botanical enquiries, in this part of the country, may be imputed, in part, to this, *that Botany*

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has never been taught in any of our Colleges, and to the difficulties that are ſuppoſed to attend it; but principally to the miſtaken opinion of its inutility in common life. This opinion being ſo generally prevalent, it may be neceſſary to obſerve, that, tho' all the medical properties and œconomical uſes of plants are not diſcoverable from theſe characters by which they are ſyſtematically arranged; yet the celebrated *Linnæus* has found, that the virtues of plants may be, in a conſiderable degree, and moſt ſafely, determined by their *natural* characters: for plants of the ſame *natural* claſs are in ſome meaſure ſimilar; thoſe of the ſame *natural* order have a ſtill nearer affinity; and thoſe of the ſame genus have very ſeldom been found to differ in their medical virtues. Thus, according to the ſexual ſyſtem, plants of the ſecond order in the third claſs are all eſculent, affording food for men, beaſts or birds; and no one ſpecies of all thoſe numerous genera have been found to be poiſonous. The ſtarry plants of the firſt order in the fourth claſs are chiefly diuretic. The rough-leaved plants of the fifth claſs and firſt order are mucilaginous; but thoſe of a diſagreeable taſte and ſmell, moſtly berry-bearing plants, are more or leſs corroſive and poiſonous. The umbelliferous plants, growing in dry places, are aromatic and ſtimulative, but in wet ground, often poiſonous. Plants of the ſixth claſs have roots, according to their ſmell or taſte, either eſculent or poiſonous. The plants with horned antheræ of the eighth and tenth claſſes are aſtringent, and their berries acid and eſculent. All the pulpy fruit of the twelfth claſs may be eaten with ſafety. Plants of the thirteenth claſs are chiefly poiſonous: but thoſe of the firſt order in the fourteenth are odoriferous, cephalic and reſolvent; and none of them are poiſonous. Nor is there any poiſonous plant belong-

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ing to the fifteenth claſs: they are generally called antiſcorbutic. Thoſe of the ſixteenth, with many filaments, are mucilaginous and emollient. The ſeventeenth has no poiſonous plant; but the ſeeds, which are food for men and other animals, are farinaceous and flatulent. Thoſe of the nineteenth are chiefly bitter; and thoſe of the twenty-fourth are moſtly ſuſpected or dangerous plants.

From the want of botanical knowledge, the groſſeſt miſtakes have been made in the application of the *Engliſh* names of *European* plants, to thoſe of *America*. Many of our moſt common vegetables are generally known, and ſome of them frequently preſcribed for medical purpoſes, by the names of plants that are entirely different, belonging to other claſſes, and poſſeſſed, no doubt, of different properties. Botanical enquiries will enable us to rectify theſe miſtakes, and to diſtinguiſh the ſeveral ſpecies of *European* or other foreign plants from thoſe that are peculiar to *America*.

We have it, alſo, in our power, from the recent ſettlement of the country, to determine, with great certainty, what vegetable productions are indigenous, and prevent thoſe doubts and diſputes hereafter, which have frequently taken place among botaniſts in old countries. For it is very improbable that any exotic plants are become ſo far naturalized as not to be diſtinguiſhable from the natives.

Was the theory of this ſcience united with its practical uſes, and employed in procuring the neceſſaries, and adding to the conveniences and ornaments of life, the vulgar opinion of its being merely ſpeculative would be removed, and could not fail of engaging a more general attention. For it is well known that the œconomical uſes of the vegetable kingdom are exceed-

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ingly numerous; not only furniſhing food and medicine for man and beaſt, materials for agriculture, and various arts and manufactures, and for many of the *delights and ornaments* of life; but it ſupplies important articles of commerce, and, in ſome countries, is the greateſt ſource of internal wealth. We are, no doubt, yet ignorant of many productions well adapted to moſt, or all, of thoſe purpoſes.

The native Indians were acquainted with the peculiar properties of certain vegetable productions, which if thoroughly underſtood by the preſent inhabitants, might be made extenſively uſeful, both in phyſic, arts and manufactures, and new branches of commerce. Their *materia medica* ſeems to have conſiſted of few articles: theſe were certain plants, powerful in their operation, and ſometimes producing ſudden and ſurpriſing effects upon the human body. Theſe ſavages ſeem to have had better ideas of the medical virtues of plants, than ſome who have imagined that vegetables, fit only for food, were the moſt proper for medicine; and that combining a great number of the moſt common plants, might be a remedy for almoſt every diſeaſe. Vegetables called poiſonous are capable of producing great and ſudden alterations in the human body: May not many of them be found, upon acurate and well-judged experiments, like ſome chymical poiſons, to be the beſt medicines? The Indians had diſcovered effectual antidotes againſt the venom of rattle-ſnakes, which muſt have been a diſcovery of great importance to them, and may, poſſibly, be reckoned among their greateſt improvements in the knowledge of medicine. Mr. *Cateſby* mentions a fact, which he ſays was well atteſted, of an Indian's daubing himſelf with the juice of the purple bindweed, a ſpecies of the convolvulus, and then handling a rattle-ſnake with his naked hands, without receiving any injury.

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These natives were, likewife, poffeffed of the art of dyeing deep and moft permanent black, red and yellow colours. Thefe colours were given to bone, horn, porcupine quills and other hard fubftances, which ftill appear, unimpaired, on fome of their ornaments and utenfils. The Spaniards are faid to have procured from the *Californian* Indians, the art of dyeing the beft black ever yet known. The plant they employ in this dye is called the cafcalote, a fmall fhrub, which abounds in that country, and may probably be found within the limits of the United States.

However defirable the knowledge of our vegetable productions may be, our progrefs muft be flow, until men, verfed in this fcience, can devote their time to the inveftigation of them. Some advances may be made by individuals collecting the productions of their own neighbourhood, and tranfmitting accounts of them, from time to time, to the Academy. How much a correfpondence of this kind has done, in perfecting the hiftory of the *Britifh* plants, will appear from the numerous botanical papers publifhed in the tranfactions of the Royal Society.

As there has never been a defcription given of the indigenous plants in this part of the country, and it being one of the ends of the inftitution of this Academy to promote the knowledge of natural hiftory, I take the liberty of communicating an account of fome of thofe which have fallen under my obfervation. They are arranged according to the *Linnæan* fyftem ; and the generic characters, where they were found to correfpond, are referred to *Linnæus's* defcription in the fifth edition of his *Genera Plantarum* : The characters of the fpecies, where there was an agreement, are taken from the tenth edition of the *Syftema Naturæ.* A few fynonyms from other authors are given, and more

more might have been added, had it been consistent with the limits of the paper. Some additional description of most of them, the times of flowering and places of growth, were thought necessary. Those plants which appear not to agree with the essential generic characters of any known genus, are inserted without any generic names, but the natural characters of the fructification are particularly described. Such as appeared doubtful are distinguished by a mark of interrogation. The *English* names are those by which the plants have been called either here or in other parts of the world, except, in a few instances, where no trivial name was known. The medical and œconomical uses which are mentioned, are inserted from the best private information that could be obtained, or selected from good authorities; many of them, in particular, from a late ingenious and useful publication by *William Withering*, M. D. entitled, "The botanical arrangement of *British* plants."

In giving this account of indigenous plants, I have had opportunity of investigating only those which were found growing within the compass of a few miles; except a small number that happened to be noticed at a greater distance. Many others have been observed, but the limits of this paper did not admit their being inserted. The generic characters of these plants were minuted from fresh blossoms in full bloom, with the aid of a microscope, and with as much attention as the little leisure I have had for botanical enquiries would admit. But not having examined any of them, for any other purpose than mere amusement, until the last summer, I doubt not errors will be found in this arrangement, which more time and further examination might have prevented. This I hope will be admitted as some apology, by every experienced botanist, who

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knows how much time is neceſſary for inveſtigating and arranging a conſiderable number of plants in a part of the country never before explored.

Ipſwich, January 26, 1784.

MONANDRIA.

MONOGYNIA.

SALICORNIA. Linn. Gen. Plant. 10.

Salicornia articulis apice compreſſis emarginatis bifidis. Syſt. Nat. *Kali geniculatum annuum.* Park.

GLASSWORT. Saltwort. Marſh Samphire. The ſtem grows about eight or ten inches high: the main ſtem divides itſelf into numerous branches. It is found on the ſea-ſhore. Bloſſoms in September.

In *Europe* a foſſil alkali is obtained from the aſhes of this plant, which is in great requeſt for making glaſs and ſoap. It is ſaid to make a pickle little inferior to ſamphire.

DIGYNIA.

BLITUM. Linn. Gen. Plant. 14.

Blitum capitellis ſpicatis terminalibus. Syſt. Nat. *Chenopodiomorus.* Boerh.

BLITE. Several ſtems riſe from the ſame root, running into many ſhort ramifications. Leaves oblong and obtuſe. Bloſſoms extremely ſmall; green with a yellow anthera. The ſmell is conſiderable, reſembling *Savin.* About *Parker*-river bridge, in *Newbury.* Auguſt.

DIANDRIA.

MONOGYNIA.

LIGUSTRUM. Linn. Gen. Plant. 18.

PRIM Privet. A ſhrub. Leaves in pairs. Bloſſoms white. Berries black. In *Lynn.* Not very common in a wild ſtate. June.

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It makes excellent hedges. The berries, gathered as ſoon as they are ripe, dye wool and ſilk of a good and durable green, with the addition of alum.

CIRCÆA. Linn. Gen. Plant. 24.

Circæa caule adſcendente, racemo unico. Syſt. Nat.

ENCHANTERS NIGHTSHADE. Bloſſoms variegated. Among buſhes in a moiſt, rich ſoil. July.

VERONICA. Linn. Gen. Plant. 25.

Veronica racemis lateralibus: pedicellis pendulis, foliis lineari-bus integerrimis. Syſt. Nat.

PIMPERNEL. Brooklime. Water Speedwell. Bloſſoms whitiſh or purpliſh. In ſwamps. June—July.

Veronica.

ONE FLOWER. Stem ſomewhat procumbent. Leaves orbicular; oppoſite on ſhort pedicles. Bloſſoms ſolitary, ſupported on ſhort flower ſtalks riſing from the *axillæ* of the leaves: they are ſmall; white, ſtriated with purple. By the way-ſide. May—July.

GOLDENPERT. The *calix* conſiſts of one leaf; tubular. The limb deeply divided into five ovate, acuminated ſegments; with two ſmall leaves growing on the outſide of the cup, oppoſite the two upper ſinuſes. *Corolla* one petal; tube very long; angular; border divided into four circular, patent, emarginated ſegments; lapping. The upper ſegment largeſt: the lower ſmalleſt. *Stamina* two ſhort filaments riſing from the tube, near together, below the upper ſegment; ſhorter than the tube. *Antheræ* circular; flattiſh; adhering together. *Germen* ovate.

Stile cylindrical; erect; of the length of the Stamina. *Stigma* concave; circular; bent downward. *Capsule* ovate; two cells; two valves. *Seeds* numerous; very small.

The stem round; erect. Leaves strap-shaped; opposite; entire. Blossoms single; on flower-stalks rising from the *axillæ* of the leaves; yellow. Around the shore of *Wenham* pond. August.

BASTARD-PEPPERGRASS. The *calix* consists of a perianthium of four erect, concave leaves; the margin coloured; two of them larger, which stand opposite. Deciduous. *Corolla* none. *Stamina* two subulated filaments with antheræ; stand opposite; of the length of the calix. *Antheræ* simple. There are four other shorter filaments without antheræ; one on each of the sides of the fertile filaments. *Germen* circular; compressed; emarginated. *Stile* very short. *Stigma* blunt and jagged. *Capsule* circular; compressed; emarginated; two cells; four valves. Two flat *seeds*; the edges tumid.

Stems round; branched. Radical leaves deeply indented; stem leaves lanceolate and slightly serrated. Blossoms very small; on fruit-stalks forming a long open spike at the extremities of the branches. Borders of fields. July—Sept.

UTRICULARIA. Linn. Gen. Plant. 29.

Utricularia nectario conico. Syst. Nat. *Lentibularia.* Ray. Syn. *Millefolium aquaticum flore luteo galericulato.* Park.

BLADDERWORT. *Common hooded Milfoil.* The roots are very small, swimming in the water, and seem scarcely to touch the ground. They send off numerous branched fibres, beset with small membranaceous bladders, appearing like black seeds. Blossoms yellow. Ponds with a muddy bottom. August.

Utricularia

Utricularia nectario carinato. Syst. Nat.

PURPLE BLADDERWORT. *Lesser hooded Milfoil.* The roots are jointed. Bladders less than the former species. Blossoms pale yellow. In muddy ponds. August.

VERBENA. Linn. Gen. Plant. 30.

Verbena diandra spicis longis, calicibus aristatis, foliis ovatis serratis. Syst. Nat.

VERVAIN. *Simplers Joy.* The stems are quadrangular. Leaves stand opposite. Blossoms in a long close spike; pale blue. Common by road-sides. July—Sept. There are two or three varieties of this species of the *Verbena* very common.

It is said that the Surgeons of the *American* army, at a certain period when a supply of medicine could not be obtained, substituted a species of the *Verbena* for an emetic and expectorant, and found its operation kind and beneficial.

LYCOPUS. Linn. Gen. Plant. 31.

Lycopus foliis æqualiter serratis. Syst. Nat.

WATER HOREHOUND. *Gipsie.* The stem four cornered. Leaves opposite. Blossoms whitish; surrounding the stem at the joints. Borders of meadows. August.

This plant has been mistaken for a species of the *Veronica*, and is generally known by the name of *Paul's Betony*. It is said the juice will give a permanent colour to linen, wool and silk, that will not wash out.

TRIANDRIA.

MONOGYNIA.

IRIS. Linn. Gen. Plant. 57.

Iris corollis imberbibus, germinibus trigonis, caule ancipiti. Syst. Nat.

BLUE-FLAG.

BLUE-FLAG. The leaves are ſword-ſhaped. Bloſſoms blue variegated with white, yellow and purple. In wet meadows. June.

A decoction of the freſh roots is a powerful cathartic, and will ſometimes produce evacuations when other means fail; but it is too draſtic for common uſe. The juice of the freſh roots may be given in doſes of 60 or 80 drops every two hours. Dr. *Withering* ſays the freſh roots of the yellow water flag have been mixed with food of ſwine bitten by a mad dog, and they eſcaped the diſeaſe, when others, bitten by the ſame dog, died raving mad. The root loſes moſt of its acrimony by drying.

XYRIS? Linn. Gen. Plant 59.

YELLOWEYED-GRASS. The *corolla* conſiſts of three ovate, patent, entire petals. The claws narrow; of the length of the *calix*. *Nectaria* three filiform filaments between the petals, longer than the calix, terminating in numerous long hairs. Three very ſhort *filaments* riſing from the petals in the mouth of the bloſſom. *Capſule* membranaceous; one cell; three valves; oblong; compreſſed on one ſide. The other parts agree with *Linnæus*'s deſcription.

The ſtem flattiſh; naked; erect. Radical leaves narrow; tapering to a point. Bloſſoms in an head on the ſummit of the ſtem; bright yellow. On banks of ponds. Auguſt.

CYPERUS. Linn. Gen. Plant. 61.

Cyperus culmo triquetro, umbellæ ſpiculis capitatis oblongis ſeſſilibus, involucris longiſſimis ſerrato-aſperis? Syſt. Nat.

GALANGALE. In open ſwamps. Auguſt.

SCIRPUS. Linn. Gen. Plant. 62.

Scirpus culmo tereti nudo, ſpicis ovatis pluribus pedunculatis terminalibus. Syſt. Nat.

BULLRUSH.

BULLRUSH. In ponds and rivers. August.

When properly cured it makes very neat bottoms to chairs; but they will be much stronger mixed with the leaves of the cat's tail flag, though somewhat coarser.

Scirpus culmo triquetro nudo acuminato, panicula spicis conglomerata laterali. Syst. Nat.

THREE CORNERED RUSH. Banks of ponds and rivers. Aug.

ERIOPHORUM. Linn. Gen. Plant. 63.

Eriophorum culmis foliosis teretibus, foliis planis, spica erecta. Syst. Nat. *Gramen juncoides lanatum alterum danicum.* Park.

COTTONGRASS. Pussy. Mossy meadows. May.

The down of the heads has been used for stuffing pillows and making wicks of candles.

The indigenous grasses of the second order are numerous, but the limits of this paper would not admit of their being inserted. A description of these and other native grasses may be the subject of another paper.

TRIGYNIA.

MOLLUGO. Linn. Gen. Plant. 99.

Mollugo foliis verticillatis cuneiformibus acutis, caule subdiviso decumbente, pedunculis unifloris. Syst. Nat. *Mullugo foliis sæpius septenis lanceolatis.* Gronov.

CARPET-WEED. Stem divided into numerous branches, spreading on the ground. Blossoms greenish white; in clusters at the joints. About pathways. July.

TETRANDRIA.

MONOGYNIA.

ARUM Americanum, *betæ folio.* Catesb. Nat. Hist.

SCUNK CABBAGE. Scunkweed. The calix consists of a very large, permanent *Spatha*; of a thick, porous substance, approaching

proaching to an ovate form; open on one ſide, and bellied out on the oppoſite; the margin auriculated at the baſe, and ſomewhat twiſted at the apex. The *Spadix* within the *Spatha*. The florets numerous, placed around the receptacle in an oval form; and are ſo compact as to appear like a ſolid body, thick ſet with ſmall, regular protuberances on its ſurface. No *Calix*. *Corolla* four erect, very thick, narrow, obtruncated petals. *Stamina* four flattiſh filaments riſing from the receptacle; longer than the corolla. *Antheræ* oblong. *Germen* convex. *Stile* cylindrical; rather longer than the ſtamina. *Stigma* bifid. *Seeds* large; roundiſh; ſingle; incloſed within the receptacle.

The firſt appearance of this ſingular plant is the flower. After the flower is arrived to a ſtate of perfection, the leaves appear at a ſmall diſtance from the flower ſtalk, in a conic form, very cloſely rolled together. As they riſe they expand; nearly ovate; ſupported on foot ſtalks. The plant has no ſtem. The globe of flowers is nearly of the colour of the ſpatha, which is beautifully variegated with ſcarlet and yellow. Common in ſwamps and borders of meadows. April—May.

This plant, which is found native no where but in *North-America*, has been conſidered by botaniſts as a ſpecies of the *Arum*. But the florets are hermaphrodite, having each of them diſtinct and perfect corolla, ſtamina and piſtil. It therefore belongs to the firſt order of this claſs, and is to be arranged among the aggregate flowers with a common perianthium. The fructification ſo eſſentially differs from all the genera of this order, it muſt, undoubtedly, be conſidered as a new genus. The vulgar name, by which it is, here, generally known, is taken from its very rank and diſagreeable ſmell, nearly reſembling that of a ſcunk or polecat.

The

The roots dried and powdered are an excellent medicine in aſthmatic caſes, and often give relief when other means are ineffectual. It may be given with ſafety to children as well as to adults; to the former, in doſes of four, five or ſix grains, and to the latter, in doſes of twenty grains and upwards. It is given in the fit, and repeated as the caſe may require. This knowledge is ſaid to have been obtained from the Indians, who, it is likewiſe ſaid, repeat the doſe after the paroxiſm is gone off, ſeveral mornings, then miſs as many, and repeat it again; thus continuing the medicine until the patient is perfectly recovered. It appears to be antiſpaſmodic, and bids fair to be uſeful in many other diſorders. In collecting the roots particular care ought to be taken that the *white hellebore*, or *poke root*, which ſome people call ſcunk weed, be not miſtaken for this plant, as the conſequence might be fatal. There is an obvious diſtinction—the hellebore has a ſtalk, but the ſcunk cabbage has none.

CEPHALANTHUS. Linn. Gen. Plant. 105.

Cephalanthus foliis oppoſitis terniſque. Syſt. Nat.

GLOBE-FLOWER SHRUB. Pond Dogwood. Button Buſh. The florets form a perfect globe, and when the fruit ſtalk is ſeparated it does not readily appear in what part of the globe it was inſerted. The bloſſoms are ſnow-white, fragrant and beautiful when in full bloom. Common in watery ſwamps and pond-holes. July—Auguſt.

HEDYOTIS. Linn. Gen. Plant. 110.

Hedyotis foliis lineari-lanceolatis, caule herbaceo dichotomo, pedunculis geminis. Syſt. Nat.

VENUS PRIDE. Bloſſoms white or bluiſh. It ſpreads over paſtures and fields, in large beds, and gives them a white appearance. May—June.

MITCHELLA. Linn. Gen. Plant. 126.

PARTRIDGEBERRY. The ſtems trailing. Leaves orbicular-cordate; oppoſite, with large white veins. Bloſſoms white. In thick woods and ſwamps. June—July.

PLANTAGO. Linn. Gen. Plant. 133.

Plantago, foliis ovatis glabris, ſcapo tereti, ſpica floſculis imbricatis. Syſt. Nat.

PLANTAIN. Common near roads and foot-paths. June—July.

The leaves are applied, by the common people, to inflamed ſores and ſwellings. The bruiſed leaves they apply to freſh cuts.

Plantago foliis lanceolato-ovatis pubeſcentibus ſubdenticulatis, ſpicis laxis pubeſcentibus, ſcapo angulato. Syſt. Nat.

VIRGINIA PLANTAIN. In graſs land. Not common. May—June.

Plantago foliis ſemicylindraceis integerrimis baſi lanatis, ſcapo tereti. Syſt. Nat.

SEA PLANTAIN. In ſalt marſhes. July.

It is ſaid to be cultivated and ſown with clover in *North-Wales* in *Great-Britain*, and greedily eaten by horſes and cows: but *Linnæus* ſays, that cows are not fond of it.

SANGUISORBA. Linn. Gen. Plant. 136.

Sanguiſorba ſpicis longiſſimis. Syſt. Nat. *Pimpinella maxima*. Cornutus.

AMERICAN BURNET. *Snakeweed*. The leaves are winged; very long. The ſmall leaves ſerrated. The filaments and antheræ are white. In rich moiſt ground. July—September.

Its

Its growth is generally luxuriant, and makes good fodder for cattle.

CISSUS. Linn. Gen. Plant. 137.

Cissus foliis ovatis nudis setaceo—serratis. Syst. Nat.

PIGEON-BERRY BUSH. The shrub grows six or eight feet high. Leaves opposite. Blossoms in broad-topped spikes; white. Common on the banks of brooks and rivers. June.

Pigeons feed on the berries, which has been the occasion of its trivial name.

MEADOW BLUEBELLS. The *calix* is a permanent perianthium of one leaf; tubular. Tube quadrangular; limb divided into four acute, erect segments. The *corolla* one petal. Tube between funnel and bell-shaped; longer than the calix; divided into four roundish, patent segments, with ciliated margins. *Nectaria* four prominent glands in the base of the corolla. *Stamina* four triangular, erect filaments; inserted into the corolla, and of the length of the calix. *Antheræ* oblong; erect. *Germen* oblong; within the tube. *Stile* short. *Stigma* bifid; flat; circular. *Capsule* oblong, quadrangular; one cell; four valves. *Seeds* numerous; ovate; adhering to the angles of the capsule.

The stem nearly round; erect; branched. Leaves ovate; opposite; half embracing the stem. Blossoms large; single; terminating; bright blue. In moist land. Not common. September.

The blossoms open about ten o'clock in the morning, and close by two in the afternoon.

CORNUS. Linn. Gen. Plant. 139

Cornus herbacea, ramis nullis. Syst. Nat.

CORNEL. Dogberry. The ſtem is quadrangular. Leaves oval; oppoſite. From the *axillæ* of the upper leaves, two other leaves are ſent off, ſpreading laterally, which give the appearance of ſix leaves at a joint. Bloſſoms white. In woodland. May—June.

OLDENLANDIA. Linn. Gen. Plant. 143.

DOGWOOD. The leaves are ovate; acuminated. Bloſſoms in broad-topped ſpikes; white. In ſwamps and banks of rivers. July.

DIGYNIA.

HAMAMELIS. Linn. Gen. Plant. 155.

WITCH-HAZEL. The leaves are nearly inverſly ovate. Bloſſoms yellow: ſtand three or four together on ſhort flower ſtalks. In loamy land. Sept.—October.

This ſingular ſhrub does not commonly bloom until its leaves are deſtroyed by froſt, when its numerous bloſſoms make a gay and agreeable appearance; and continue until the weather becomes very cold, often until ſnow falls. The germen endures the ſeverity of our winters uninjured; for the fruit does not ripen until the next September, the time of its bloſſoming again, when ripe fruit and bloſſoms will be found on the ſame tree.

The Indians conſidered this tree as a valuable article in their *materia medica*. They applied the bark, which is ſedative and diſcutient, to painful tumors and external inflammations. A cataplaſm of the inner rind of the bark, is found to be very efficacious in removing painful inflammations of the eyes. The bark chewed in the mouth is, at firſt, ſomewhat bitter, very ſenſibly aſtringent, and then leaves a pungent, ſweetiſh taſte, which will remain for a conſiderable time. The ſpecific qualities

lities of this tree seem, by no means, to be accurately ascertained. It is, probably, possessed of very valuable properties.

CUSCUTA. Linn. Gen. Plant. 156.

Cuscuta floribus pedunculatis. Syst. Nat.

DODER. *Devil's Guts.* Among flax. July.

This plant is well known to farmers, who often have their fields of flax greatly injured by its twining about the stalks. It is parasitical. When it has ascended the stalk of flax, or whatever plant is next to it, a number of very small papillæ are sent off from the inner surface of the vine, which insinuate themselves into the bark of the plant. The root then decays, and it receives its nourishment from the plant which it twines about. The whole plant is bitter; and it affords a pale reddish colour.

TRAILING COCKSPUR. *Calix* none; except the corolla be called the calix. *Corolla* one petal; flat; coloured without and within. Limb deeply divided into four ovate acuminated segments. Deciduous. *Stamina* four short, filiform, erect filaments; standing upon the corolla. *Antheræ* globular. *Germen* below; double. Stiles two; erect; passing through the base of the corolla. *Stigmata* globular. Two *seeds*, or nuts, contained in a rind thick set with hooked spines.

The generic characters of this plant approach those of the *Aphanes*, but seem so essentially to differ as not to admit its being placed under that genus.

The stem trailing; four square; the edges tumid, and beset with short, hooked spines. Leaves lanceolate; six at a joint. Blossoms reddish white; placed in the *axillæ* of the leaves. Borders of brooks and ditches. August.

UPRIGHT

UPRIGHT COCKSPUR. Stems erect; quadrangular. Leaves ovate; four at a joint. Stem-leaves rough: somewhat woolly. Blossoms white. Open wood land. June.

TETRAGYNIA.

POTAMOGETON. Linn. Gen. Plant. 160.

Potamogeton foliis oblongo-ovatis petiolatis natantibus. Syst. Nat. *Fontalis major latifolia vulgaris.* Park.

PONDWEED. Blossoms in spikes; yellowish. In ponds and rivers. August.

The leaves afford an agreeable shade to pickerel.

PENTANDRIA.

MONOGYNIA.

CYNOGLOSSUM. Linn. Gen. Plant. 168.

Cynoglossum staminibus corolla brevioribus, foliis lato—lanceolatis tomentosis sessilibus. Syst. Nat.

HOUNDSTONGUE. Blossoms pale blue. Road sides in *Dedham.* July.

It has a very disagreeable smell. Dr. *Withering* observes, that both the root and leaves have been suspected to possess narcotic properties; but that others will not admit the fact.

SYMPHYTUM. Linn. Gen. Plant. 170.

Symphytum foliis ovato—lanceolatis decurrentibus. Syst. Nat. *Symphytum magnum.* Raii. Syn.

COMFREY. Blossoms yellowish white. In moist land. Not common growing wild. June.

It is cultivated in gardens; and though it is sometimes found growing wild, there seems to be some doubt whether it be indigenous.

The

The roots are much uſed by the common people for ſprains. They are glutinous and mucilaginous. The leaves give a grateful flavour to cakes and panadoes.

CORTUSA. Linn. Gen. Plant. 181.

Cortuſa calycibus corollam excedentibus. Syſt. Nat.

BEARSEAR SANICLE. The ſtems are round; erect. Leaves oblong in pairs. Bloſſoms yellow. In moiſt ground. July.

HOTTONIA. Linn. Gen. Plant. 186.

Hottonia pedunculis verticillato—multifloris. Syſt. Nat. *Millefolium aquaticum floridum ſeu viola aquatica.* Park. *Hottonia.* Boerh.

WATER VIOLET. *Featherfoil.* Leaves winged, ſpreading on the ſurface of the water in a ſtellate form. Bloſſoms white. In ſtanding waters and ditches. May—June.

LYSIMACHIA. Linn. Gen. Plant. 188.

Lyſimachia foliis quaternis ſubſeſſilibus, pedunculis quaternis unifloris. Syſt. Nat.

YELLOW WILLOWHERB. *Pimpernel.* *Looſeſtriſe.* Stem round; hairy. Leaves ovate. Bloſſoms bright yellow. In wood land. June.

MEADOWSWEET. *Moneywort.* Stems erect. Leaves oblong; five or ſix at a joint; marked with white or red ſpecks. Bloſſoms ſingle; on long flower ſtalks; yellow. Borders of meadows, or brooks. June.

ANAGALLIS. Linn. Gen. Plant. 189.

Anagallis foliis indiviſis, caule procumbente. Syſt. Nat. *Anagallis flore phœniceo.* Park.

PIMPERNEL. Bloſſoms red. In clayey ground. June.

Anagallis

Anagallis foliis sinuatis. Syst. Nat.

GROUNDSTAR. Blossoms white, tinged with red. Amongst grass by the way side. May—Aug.

AZALEA. Linn. Gen. Plant. 195.

Azalea foliis ovatis, corollis pilosis, staminibus longissimis. Syst. Nat.

AMERICAN HONEYSUCKLE. Swamp Pink. Blossoms in a kind of tuft at the termination of the branches. They are white; but the deep red globules at the ends of the hairs on the corolla and stamina give the appearance of a red tinge. Common in low, swampy land. June.

This shrub, when in full bloom, makes an elegant appearance. The blossoms are fragrant, and have been made into conserves. It is easily propagated in gardens, and may doubtless be improved by cultivation. We have few exotic flowering shrubs superior to it.

CONVOLVULUS. Linn. Gen. Plant. 198.

Convolvulus foliis sagittatis utrinque acutis, pedunculis unifloris. Syst. Nat.

BINDWEED. Small Convolvulus. Blossoms white or striped. In corn fields. July.

Convolvulus foliis sagittatis postice truncatis, pedunculis tetragonis unifloris. Syst. Nat. *Convolvulus major albus.* Park.

GREAT CONVOLVULUS. Two floral leaves close to the calix. Blossoms white; or white and red. Common in hedges, and by stone walls. July.

Catesby, in his history of the *Carolinas*, mentions an Indian who daubed himself with the juice of a species of the Convolvulus, and then handled a rattle-snake without receiving injury.

Scammony.

Scammony, Dr. *Withering* ſays, is the inſpiſſated juice of a ſpecies of Convolvulus ſo much reſembling this, that they are with difficulty diſtinguiſhed. Can it then, ſays he, be worth while to import Scammony from *Aleppo*, at a conſiderable annual expence, when a medicine, with the very ſame properties, grows ſpontaneouſly in many of our hedges? If the preparation of Scammony would be a ſaving to *England*, it muſt certainly be a much greater to *America*, in proportion to the quantity uſed. Beſides, as the imported Scammony is often very impure, and as there is ſo much difference in the purgative virtue of ſome maſſes of it, and that of others, that it is ſeldom to be depended upon alone in extemporaneous practice, might it not be prepared here much purer, and be more uniform in its virtue? Notwithſtanding the roots of the Convolvulus is a very acrid purgative to the human race, hogs will eat it in large quantities without any ill effects.

IPOMOEA. Linn. Gen. Plant. 199.

Ipomoea foliis cordatis integerrimis glabris lacunoſis, pedunculis bifloris. Syſt. Nat.

AMERICAN JASMINE. Leaves ſtand oppoſite. Bloſſoms yellow, tinged with red. Among hazel buſhes. Very rare. July.

AMERICAN TEA. The *calix* a very ſmall permanent rim, ſurrounding the receptacle; ſcarcely viſible. *Corolla* one petal; tubular. Limb divided into five acuminated ſegments; rolled inward. *Nectaria* five hooded petals, with long, filiform claws, inſerted into the corolla below the ſinuſes of the ſegments; erect; longer than the ſegments of the corolla. *Stamina* five ſubulated filaments ſtanding upon the corolla juſt

below the petals of the nectarium. Antheræ globular; covered by the hooded petals of the nectarium. *Germen* above; globular. *Stile* cylindrical; erect; shorter than the stamina. *Stigma* trifid. *Capsules* three; each one cell; one valve. *Seeds* one in each cell; ovate compressed.

Stems woody. Leaves ovate; serrated; acuminated. Blossoms in long, terminating, open spikes; snow white. By fences, and among bushes in loamy land. July.

The leaves of this shrub have been much used by the common people, in some parts of the country, in the room of *India* tea; and is, perhaps, the best substitute the country affords. They immerse the fresh leaves in a boiling decoction of the leaves and branches of the same shrub, and then dry them with a gentle heat. The tea, when the leaves are cured in this way, has an agreeable taste, and leaves a roughness on the tongue somewhat resembling that of the bohea tea.

CAMPANULA? Linn. Gen. Plant. 201.

Campanula foliis subovatis integerrimis, caulibus diffusis. Syst. Nat.

VENUS LOOKING-GLASS. Blossoms yellow. On high land. July.

PHYTEUMA. Linn. Gen. Plant. 203.

Phyteuma capitulo subfolioso, foliis omnibus lanceolatis. Syst. Nat.

RAMPION. Blossoms white with blue veins. Moist land. July.

LONICERA. Linn. Gen. Plant. 210.

Lonicera racemis terminalibus, foliis serratis. Syst. Nat.

HONEYSUCKLE. Bastard Cherry. Blossoms yellow, tinged with red. Among bushes in loamy land. June.

VERBASCUM. Linn. Gen. Plant. 217.

Verbascum foliis decurrentibus utrinque tomentosis. Syst. Nat.

MULLEIN. Blossoms in long terminating spikes; yellow. Common in old fields. July.

Verbascum foliis amplexicaulibus oblongis glabris, pedunculis solitariis. Syst. Nat.

MOTH MULLEIN. Blossoms yellowish white. By the road sides in *Lynn*. July.

DATURA. Linn. Gen. Plant. 218.

Datura pericarpiis spinosis erectis ovatis. Syst. Nat.

APPLEPERU. Stramonium. Thornapple. Blossoms white with a tinge of purple. The upper leaves have been observed to rise up and enclose the blossoms at night. Common by the way sides. August.

This plant is said to be an exotic, and that it is not found growing at any great distance from the sea. The seeds taken internally bring on delirium; large doses would, no doubt, prove fatal. The leaves applied to the feet, or part affected, have been found efficacious in removing spasms; and applied in cataplasms give ease in external inflammations. An ointment prepared from the leaves gives ease likewise in external inflammations and hæmorrhoids. The *Edinburgh* College direct an extract to be prepared by evaporating the expressed juice of the leaves. Its medical properties undoubtedly merit attention. None of the herbivorous animals will eat it.

HYOSCYAMUS. Linn. Gen. Plant. 219.

Hyoscyamus foliis amplexicaulibus. Syst. Nat.

HENBANE. Blossoms purple and brown; clammy. Common amongst rubbish, and by road sides. July.

The feeds, the leaves, and the roots, Dr. *Withering* obferves, are all poifonous. Madnefs, convulfions, and death, are the general confequence. In a fmaller dofe, they occafion giddinefs and ftupor. The *Edinburgh* College order the expreffed juice of the plant to be evaporated to an extract. In this ftate, the Doctor fuppofes, it may be advantageoufly joined with opium, where the effects of that medicine are defirable, and coftivenefs is to be avoided. There is no doubt, he fays, of its being a ufeful medicine under proper management. The dofe is from half a fcruple to half a dram. It is faid, that the leaves fcattered about a houfe will drive away mice.

SOLANUM. Linn. Gen. Plant. 224.

Solanum caule inermi frutefcente flexuofo, foliis fuperioribus haftatis, racemis cymofis. Syft. Nat.

BITTER-SWEET. Bloffoms purple, with fpots of white. Common about fences in moift land. June.

Boerhaave fays, it is a medicine far fuperior to China and Sarfaparilla as a fweetner and reftorative. *Linnæus* fays, an infufion of the young twigs is an admirable medicine in acute rheumatifms, inflammations, fevers, and fuppreffion of the lochia. Dr. *Hill* fays, he has found it very efficacious in the afthma.

Solanum caule inermi herbaceo, foliis ovatis dentato—angulatis, umbellis nautantibus. Syft. Nat.

NIGHTSHADE. Bloffoms white. Berries black. Common among rubbifh. July.

Dr. *Withering* fays, from one to three grains of the leaves infufed in boiling water, and taken at bed time, occafions a copious perfpiration ; increafes fecretions by the kidneys, and generally

generally purges more or leſs the following day. Theſe properties, judiciouſly applied, render it capable of doing eſſential ſervice in ſeveral diſeaſes. But its effects on the nervous ſyſtem are ſo uncertain, and ſometimes ſo conſiderable, that it muſt ever be adminiſtered with the greateſt caution. The leaves applied externally, eaſe pain and abate inflammations.

TIVERTWIG. American *Mezerion.* The generic characters do not entirely agree with the Solanum; but they approach nearer to this than any other genus. Stems woody; twining about ſhrubs or trees; branched. Leaves ovate; ſerrated; acuminated. Bloſſoms greeniſh white. Berry pale red. In hedges and wood land. June.

It is uſed with ſucceſs in diſcuſſing indurated tumors. Farmers apply it to ſwellings in cows bags. Phyſicians of diſtinguiſhed characters ſay, that the roots anſwer as valuable a purpoſe, in venereal caſes, as the Mezerion.

RIBES. Linn. Gen. Plant. 247.

Ribes inerme, racemis piloſis, floribus oblongis. Syſt. Nat.

BLACK CURRANT. Bloſſoms yellowiſh. Berries black. It is rarely found growing naturally here, but is cultivated in gardens. In ſome parts of the eaſtern country it is ſaid to be found in great plenty, particularly near *Kennebeck-river.*

A jelly made of the fruit is celebrated in the Philoſophical Tranſactions of the Royal Society for curing very bad kinds of ſore throat. It has been found to anſwer very well here, particularly in that ſpecies of the ſore throat in which the tonſils ſuppurate. It ought to be applied early and frequently. When the fruit could not be obtained, an infuſion of the bark, ſweetened with honey, and uſed as a gargle, has proved beneficial.

Dr.

Dr. *Withering* ſays, the juice of the berries is frequently boiled down into an extract, with the addition of a ſmall proportion of ſugar, which is called rob, and is much uſed in ſore throats, but chiefly in thoſe of the inflammatory kind. An infuſion of the young roots is uſeful in fevers of the eruptive kind; and in the dyſenteric fevers of cattle. The fruit is often put into rum inſtead of black cherries. The tender leaves will give a tinge to rum nearly reſembling brandy.

Ribes ramis aculeatis, petiolorum ciliis piloſis, baccis hirſutis. Syſt. Nat.

GOOSE BERRY. Bloſſoms greeniſh white. Berries rediſh, or white. Common in moiſt hedges, and banks of ditches. May.

The fruit is very agreeable, either as nature preſents it, or made into a jelly. It is much uſed in tarts. An equal weight of picked Gooſe Berries and pure ſugar put over the fire, will ſpontaneouſly ſeparate a liquor which becomes a moſt agreeable jelly. The fruit of the wild Gooſe Berry may be greatly improved by cultivation.

HEDERA. Linn. Gen. Plant. 249.

Hedera foliis ovatis lobatiſque. Syſt. Nat. *Hedera trifolia Canadenſis.* Corn.

POISON IVY. Bloſſoms white, with purple or black veins. Berries black. Common in moiſt hedges and meadows. June.

It aſcends trees adhering by numerous linear tendrils, which are ſent off from the body of the ſtem, inſinuating their ſharp ends into the bark of the tree. It produces the ſame kind of inflammations and eruptions, in certain conſtitutions, as the poiſon wood tree. A milky juice exſudes from the ſtalks and leaves,

leaves, which will ſtain linen a deep and unfading black. This juice is ſaid to have been uſed by the Indians in ſtaining the hardeſt ſubſtances a deep and permanent black. Country people employ it in making ink. Some have ſuppoſed its properties are not inferior to thoſe of the *Japan* varniſh tree.—It is undoubtedly worthy of attention.

Hedera foliis quinatis ovatis ſerratis. Syſt. Nat.

WOODBINE. Ivy. Bloſſoms greeniſh white. Berries dark brown. Moiſt wood land. July.

It is planted by walls and buildings, upon which it will aſcend, ſupporting itſelf by a ſingular kind of degitate tendrils.

VITIS. Linn. Gen. Plant. 250.

Vitis foliis cordatis dentato—ſerratis utrinque nudis Syſt. Nat.

GRAPE. Bloſſoms white. Berries white or purple. Common in moiſt land, and ſwamps.

DIGYNIA.

APOCYNUM. Linn. Gen. Plant. 269.

Apocynum caule rectiuſculo herbaceo, foliis ovatis utrinque glabris, cymis terminalibus. Syſt. Nat.

DOGSBANE. Umbrella weed. Bloſſoms white, ſtriped with red. Borders of wood land. July.

Apocynum caule erecto fruteſcente, foliis lanceolato—ovalibus, corollis acutis : fauce villoſis. Syſt. Nat.

RIVER SWALLOWWORT. Bloſſoms yellowiſh white. At *Winnipeſoket-falls*, in *Providence-river.* July.

ASCLEPIAS. Linn. Gen. Plant. 270.

Aſclepias foliis lanceolato—ellipticis, caule ſimplici glabro, nectarii-corniculis conniventibus. Syſt. Nat.

SILKWEED,

SILKWEED. Bloſſoms rediſh. Common by the road ſides, and in paſtures. July.

The ſeeds are contained in large pods, and are crowned with white down, extremely fine and ſoft, reſembling ſilk, which has occaſioned the name of Silkweed. It may be carded and ſpun into an even thread, which makes excellent wickyarn. The candles will burn equally free, and afford a clearer light than thoſe made of cotton wicks. They will not require ſo frequent ſnuffing, and the ſmoke of the ſnuff is leſs offenſive. The texture of the down is weak, but ſufficiently ſtrong for dipped candles. If greater ſtrength ſhould be neceſſary, a ſmall quantity of cotton wool may be mixed with the down. Large quantities may be eaſily collected, and the tallow-chandlers might, doubtleſs, be ſupplied for leſs than half the price of cotton yarn.

Aſclepias foliis ovatis ſubtus villoſis, caule ſimplici, umbellis erectis, nectariis reſupinatis. Syſt. Nat.

INDIAN HEMP. Bloſſoms rediſh. In moiſt land. July.

The fibres of the bark are ſtrong, and capable of being wrought into a fine ſoft thread; but it is very difficult to ſeparate the bark from the ſtalk. It is ſaid to have been uſed by the Indians for bow-ſtrings.

Aſclepias foliis lanceolatis glabris, caule ſimplici, umbellis erectis lateralibus ſolitariis. Syſt. Nat.

SWALLOWWORT. Bloſſoms white. About fences in moiſt land. July.

Aſclepias foliis lanceolatis, caule ſuperne diviſo, umbellis terminalibus congeſtis. Syſt. Nat.

MONEYWORT. Bloſſoms purple. In old fields. July.

CHENOPODIUM.

CHENOPODIUM. Linn. Gen. Plant. 273.

Chenopodium foliis ovatis dentatis acutis, racemis ramosis nudis. Syst. Nat.

SOWBANE. Fruit green or reddish. About barns. August.

SALSOLA. Linn. Gen. Plant. 275.

Salsola herbacea decumbens, foliis subulatis spinosis scabris, calycibus marginatis axillaribus. Syst. Nat.

KELPWORT. Blossoms greenish. On the sea shore. September.

Salsola herbacea erecta, foliis subulatis spinosis lævibus, calycibus ovatis. Syst. Nat.

GLASSWORT. Blossoms greenish. On the sea shore. July.

ULMUS. Linn. Gen. Plant. 281.

Ulmus foliis duplicato-serratis : basi inæqualibus. Syst. Nat.

ELM. Blossoms in broad-topped spikes. Bark of the trunk cracked and rough. In loamy land. April.

A decoction of the inner bark, drank freely, is said to carry off the water in dropsies. The bark dried and ground to powder, hath been mixed with meal, in *Norway*, to make bread in times of scarcity.

Elmus foliis æqualiter serratis : basi inæqualibus. Syst. Nat.

SMALL ELM. Common in moist land and swamps.

GOLDEN VINE. *Calix* a perianthium with five small, obtuse segments. *Corolla* one petal ; bell-shaped. Limb divided into five obtuse, patent segments. *Stamina* five erect filaments inserted into the corolla at the sinuses of the segments. *Antheræ*

 simple.

ſimple. *Germen* large ; globular. *Stiles* two ; very ſhort. *Stigmata* ſimple. *Capſule* globular ; two cells ; four valves. *Seeds* two ; globular.

The ſtem is of the ſize of a pack-thread ; twining. It is paraſitical ; attaching itſelf to whatever vegetable is next to it, by numerous papillæ. It has many branches. No leaves. Bloſſoms in bunches ; placed in the *axillæ* of the branches ; ſnow white. Common in hedges, and among buſhes in moiſt ground. July.

SANICULA. Linn. Gen. Plant. 289.

Sanicula foliis radicalibus compoſitis : foliolis ovatis. Syſt. Nat.

SANICLE. Bloſſoms greeniſh. By ſtone walls, and among buſhes. June.

LASERPITIUM. Linn. Gen. Plant. 306.

Laſerpitium foliolis trilobis inciſis. Syſt. Nat.

GREAT LASERWORT. *Wild Angelica*. Bloſſoms white. On high land. Not common. June.

ANGELICA. Linn. Gen. Plant. 309.

Angelica foliis æqualibus ovatis inciſo—ſerratis. Syſt. Nat.

ANGELICA. American *Maſterwort*. Bloſſoms greeniſh white. Borders of fields in moiſt land. July.

It is warm, acrid and aromatic. The ſtems are frequently candied by the country people.

SIUM. Linn. Gen. Plant. 310.

Sium foliis pinnatis, umbellis terminalibus. Syſt. Nat.

WILD PARSLEY. *Water parſnip*. Bloſſoms white. In watery places. July.

TRIGYNIA.

TRIGYNIA.

RHUS. Linn. Gen. Plant. 331.

Rhus foliis pinnatis ovatis acuminatis ferratis fubtus tomentofis. Syft. Nat.

HAIRY SUMACH. Bloffoms greenifh white. Fruit fcarlet. About fields. July.

Rhus foliis pinnatis ferratis lanceolatis utrinque nudis. Syft. Nat.

VELVET SUMACH. Bloffoms greenifh white. Fruit in large, ovate, clofe panicles; crimfon. Common in a loamy foil. July.

Rhus foliis pinnatis integerrimis, petiolo membranaceo articulato. Syft. Nat.

DWARF SUMACH. Bloffoms greenifh white. Panicles open. Fruit pale red. In rocky ground. July.

Thefe fpecies of Sumach are moderately aftringent. An infufion of the berries, fweetened with honey, is fometimes ufed for a gargle in fore throats, and for cleanfing the mouth in putrid fevers. The country people employ them in feveral kinds of dyes. With copperas or vitriol they give a good black; but it foon grows rufty. They are ufed in the preparation of *Morocco* and other leather. *Carver* fays, the Indians, in order to render their tobacco more agreeable in fmoking, mix with it equal quantities of the leaves of Sumach.

Rhus foliis pinnatis integerrimis, petiolo integro. Syft. Nat. *Arbor* Americana *alatis foliis fucco venenato.* Plukenet. *Toxicodendron foliis alatis, fructu purpureo pyriformi fparfo.* Catefby.

POISON WOOD. Swamp Sumach. Bloffoms whitifh. Panicles open. Fruit yellowifh; fmall; pair-fhaped. Common in fwamps. June.

The milky juice ſtains linen a dark brown. The whole ſhrub is, in a high degree, poiſonous to certain conſtitutions. The poiſon will be communicated by touching or ſmelling any part of the ſhrub. In about forty-eight hours inflammation appears on the ſurface of the ſkin, in large blotches; principally on the extremities, and on the glandulous parts of the body. Soon after, ſmall puſtules riſe in the inflamed parts, and fill with watery matter, attended with very conſiderable burning and itching. In two or three days the eruptions ſuppurate; after which the inflammation ſubſides, and the ulcers heal in a ſhort time. It operates, however, ſomewhat differently in different conſtitutions; and what is ſingular, ſome conſtitutions are incapable of being poiſoned with it at all. It has been obſerved, that perſons of irritable habits are the moſt liable to receive it.

Rhus foliis ternatis: foliolis petiolatis ovatis nudis integerrimis, caule radicante. Syſt. Nat.

CREEPING IVY. Bloſſoms whitiſh. In meadows. June. The juice will ſtain linen a deep black. It is leſs poiſonous than the Poiſon Wood.

The Abbé *Sauvages* ſtained linen a black colour with the juice of the *Toxicodendron Caroliniarum foliis pinnatis, floribus minimis herbaceis,* which it retained, notwithſtanding a great number of waſhings in lye. The juice adhered, without the leaſt acrimony, to the cloth, with more force than any other known preparation. The Abbé *Mazeas* made trial of the juice of the *Hedera trifolia Canadenſis.* Corn. The inſtant, he ſays, the cloth was expoſed to the ſun, it became the fineſt black he had ever ſeen. It was put into a boil of ſoap, and after being dried,

dried, into a ſtrong lye of aſhes, but neither of them made the leaſt alteration. Mr. *Philip Miller* ſays, the *American* Toxicodendron, with the juice of which the Abbé *Sauvages* ſtained his linen, is the ſame ſpecies of plant from which the inhabitants of *Japan* procure the varniſh with which they ſtain all their utenſils : and recommends it to the inhabitants of the (then) *American* colonies to collect this varniſh, which, he ſays, may not only produce much profit to themſelves, but alſo become a national advantage. But Mr. *John Ellis* inſiſts upon there being a difference in their ſpecific characters. [*Philoſ. Tranſ. Royal Society. Vol.* xlix. *p.* 157, 161, 866.]

The leaves of ſome of our Poiſon Wood trees are entirely ſimilar to Dr. *Kæmpfer*'s figure of the *Sitz, vel Sitz dſju, vulgo urus ſeu urus noki. Arbor vernicifera legitima folio pinnato, Juglandis fructu, recemoſo Ciceris facie* : and the only difference between the leaf of one ſpecies of our Sumach and the leaf of the varniſh tree, raiſed from ſeeds ſent to the Royal Society, is, that, the middle part, and not the baſe of the leaf of Sumach, is ſerrated. Conſidering the great profits that have accrued from the varniſh tree, to the two large empires of *China* and *Japan*, and the advantages of a deep, permanent and incorroſive black dye, it muſt be thought worth while to make experiments on all our ſpecies of the Hedera and Rhus. If we ſhould fail of ſucceſs with reſpect to the native plants, there can be no doubt but that the varniſh tree of *Japan*, could the ſeeds be procured in a vegetitive ſtate, would flouriſh in *America*.

VIBURNUM. Linn. Gen. Plant. 332.

Viburnum foliis cordatis ſerratis venoſis ſubtus tomentoſis. Syſt. Nat.

MEALTREE.

MEALTREE. Bloſſoms white. Berries black. In moiſt wood land. June.

Viburnum foliis lobatis, petiolis glanduloſis. Syſt. Nat.

WATER ELDER. Bloſſoms white. Berries red. In *Glouceſter,* in wet land. June.

CASSINE ? Linn. Gen. Plant. 333.

Caſſine foliis oblongis ſerratis. Syſt. Nat.

WINTERBERRY. The number of filaments is from five to ſeven, and the number of ſeeds equal to the number of filaments. Bloſſoms white. Berries red, and generally remain on the ſhrub through the winter. In ſwamps. June.

SAMBUCUS. Linn. Gen. Plant. 334.

Sambucus cymis quinquepartitis, caule arboreo. Syſt. Nat.

ELDER. Bloſſoms white. Berries black. In ſwamps, and moiſt land. May.

Dr. *Withering* obſerves, that the inner green bark is purgative, and may be uſed with advantage where acrid purgatives are requiſite. In ſmall doſes it is diuretic, and hath done eminent ſervice in obſtinate glandular obſtructions, and in dropſies. If ſheep that have the rot are placed in a ſituation where they can get at the bark and the young ſhoots, they will ſoon cure themſelves. The leaves are purgative like the bark, but more nauſeous. The inner bark and leaves are ingredients in ſeveral cooling ointments. A decoction of the flowers, taken internally, is ſaid to promote expectoration in pleuriſies. If the flowers are freſh gathered, they looſen the belly. Externally, they are uſed in fomentations to eaſe pain and abate inflammation. They will give a flavour to vinegar. A rob prepared from the berries

berries is a gentle opener, and promotes perſpiration. An infuſion of the dried berries is given to children. The flowers kill turkeys, and the berries are poiſonous to poultry. The freſh leaves laid round young cucumbers, melons or cabbages, are a good preſervative againſt worms and inſects. It is ſaid, if turnips, cabbages, fruit trees or corn, (which are ſubject to blights from a variety of inſects) are whipped with the green leaves and branches of Elder, the inſects will not attack them. The green leaves are ſaid to drive away mice.

ALSINE. Linn. Gen. Plant. 342.

Alſine petalis bipartitis, foliis ovato—cordatis. Syſt. Nat.

CHICKWEED. Leaves oppoſite. Bloſſoms white; open about nine in the morning, and cloſe at noon. Common in gardens, and rich cultivated ground. June—September.

If it be boiled when young, it can hardly be diſtinguiſhed from ſpring ſpinach. What is called the ſleep of plants is very apparent in the Chickweed. At night the leaves approach, in pairs, ſo near as to incloſe, within their upper ſurface, the rudiments of the young ſhoots and the ends of the branches. As the dew goes off in the morning they expand.

PENTAGYNIA.

ARALIA. Linn. Gen. Plant. 346.

Aralia caule petioliſque aculeata, foliolis inermibus villoſis. Syſt. Nat.

BERRY-BEARING ANGELICA. *Shot Buſh.* *Pigeon Weed.* Bloſſoms white. Berries black. Common in new plantations. July.

Aralia caule folioſo herbaceo lævi. Syſt. Nat.

PETTYMORREL.

PETTYMORREL. *Life of Man.* Bloſſoms greeniſh white. Berries black. In moiſt, rich wood land. July.

It is aromatic. The berries give ſpirits an agreeable flavour. The bark of the root and berries are a good ſtomachic. It is ſaid to have been much uſed by the Indians for medical purpoſes.

Aralia.

SARSAPARILLA. The roots extend a long way juſt under the ſurface of the ground. Stems naked; divided into three leaf-ſtalks. Leaves ovate; acuminated; ſerrated; three or five on a leaf-ſtalk, in a winged form. Bloſſoms in a globular umbel, riſing from the *axillæ* of the leaf-ſtalks; white. Berries red. Common in loamy wood land. May.

The roots are aromatic and nutritious. They have been found beneficial in debilitated habits. It is ſaid the Indians would ſubſiſt upon them, for a long time, in their war and hunting excurſions. They make an ingredient in diet drinks.

STATICE? Linn. Gen. Plant. 348.

Statice caule nudo paniculato tereti, foliis lævibus. Syſt. Nat.

MARSH ROSEMARY. Bloſſoms blue. Common in marſhes. July.

The roots are powerfully aſtringent. A decoction of them is given, and uſed as a gargle, with ſucceſs, in cankers and ulcerated ſore throats.

DROSERA. Linn. Gen. Plant. 351.

Droſera ſcapis radicatis, foliis orbiculatis. Syſt. Nat.

SUNDEW. *Roſa Solis.* Bloſſoms white. In moſſy meadows. July—Auguſt.

The

The whole plant is sufficiently acrimonious to erode the ſkin. But Dr. *Withering* ſays, ſome ladies know how to mix the juice with milk, ſo as to make it an innocent and ſafe application to remove freckles and ſunburn. The juice will deſtroy warts and corns. If the juice be put into a ſtrainer, through which the warm milk from the cow is poured, and the milk ſet by for a day or two to become aceſcent, it acquires a conſiſtancy and tenacity—neither the whey nor the cream will ſeparate. In this ſtate it is uſed by the inhabitants in the north of *Sweden*, and called an extremely grateful food.

HEXANDRIA.

MONOGYNIA.

PONTEDERIA. Linn. Gen. Plant. 361.

Pontederia foliis cordatis, floribus ſpicatis. Syſt. Nat.

PICKERELWEED. Blue Spike. Bloſſoms blue. Common on the borders of ponds and rivers. July.

LILIUM. Linn. Gen. Plant. 371.

Lilium foliis verticillatis, floribus reflexis, corollis revolutis. Syſt. Nat.

MARTAGON. Curl-flowered Lily. Bloſſoms yellow, ſpotted with black. In *Taunton*, and very common in the ſtate of *Rhode-Iſland*. July—Auguſt.

Lilium foliis verticillatis, floribus reflexis, corollis campanulatis. Syſt. Nat.

YELLOW LILY. Bloſſoms yellow, with black ſpots. Common in meadows. July—Auguſt.

Lilium foliis verticillatis, flore erecto, corolla campanulata. Syſt. Nat.

RED LILY. Bloſſoms red, ſpotted with black. Common on borders of meadows. July.

UVULARIA. Linn. Gen. Plant. 373.

Uvularia foliis ſeſſilibus. Syſt. Nat.

BELLWORT. *Sweet-ſmelling* Solomon's *Seal*. Jacob's *Ladder*. Bloſſoms whitiſh. Common in wood land. May.

The young ſhoots may be eaten as aſparagus. The roots are nutritious, and are uſed in diet-drinks.

ORNITHOGALUM. Linn. Gen. Plant. 377.

Ornithogalum ſcapo anguloſo diphyllo, pedunculis umbellatis ſimplicibus. Syſt. Nat.

BETHLEMSTAR. Bloſſoms yellow. Common in graſs land and amongſt buſhes. May.

The bulbous roots are nutritious and wholeſome. It makes beautiful edgings for borders in gardens.

CONVALLARIA. Linn. Gen. Plant. 383.

Convallaria foliis amplexicaulibus plurimis, racemo terminali ſimplici ? Syſt. Nat.

SOLOMON's SEAL. Leaves alternate, and are rather ſeſſile than embracing the ſtem. Bloſſoms white. Berries red, or black. In rich wood land. May.

The young ſhoots may be eaten as aſparagus. The roots are nutritious.

Convallaria foliis cordatis. Syſt. Nat.

HAREWORT. *Adder's Tongue*. One radical leaf; two ſtem-leaves. Bloſſoms white. Berries red. Common amongſt buſhes in moiſt land. May.

In this plant we have an inſtance of the wrong application of an *Engliſh* name.—It is called *Adder's Tongue*, and miſtaken for

for one of the *ferns*, which is known by that name in *England*.

ALETRIS. Linn. Gen. Plant 387.

Aletris floribus erectis. Syst. Nat.

UNICORN. Bloſſoms white. On high land in *Killingſly*, in the ſtate of *Connecticut*. July.

It is ſaid to be uſeful in chronic rheumatiſms.

ACORUS. Linn. Gen. Plant. 392.

SWEET FLAG. *Spicewort*. The leaves are thick ; narrow ; two-edged. Bloſſoms greeniſh. Common in watery places. July.

The roots and bloſſoms are aromatic and pungent. The dried roots are carminative. They are frequently grated into water, and given to children for pain in the ſtomach and bowels. The *Turks* candy the roots, and think they are a preſervative againſt contagion.

BERBERIS. Linn. Gen. Plant. 399.

Berberis pedunculis racemoſis. Syst. Nat.

BARBERRY. *Pipperidge Buſh*. Bloſſoms yellow. Common. July.

The berries are uſed for pickles. Boiled with ſugar, they form a moſt agreeable jelly. They are uſed likewiſe as a dry ſweet-meat, and in ſugar-plumbs. An infuſion of the bark in white wine is purgative. The roots boiled in lye dye wool yellow. In *Poland*, they dye leather of the moſt beautiful yellow with the bark of the root. The inner bark of the ſtems dyes linen of a fine yellow, with the aſſiſtance of alum. It is ſaid, that rye and wheat will be injured by this ſhrub, at the diſtance of three or four hundred yards ; but only when it is

in bloſſom, by means of the *farina fœcundans* being blown upon the grain, which prevents the ears from filling.

TRIGYNIA.

RUMEX. Linn. Gen. Plant. 407.

Rumex floribus hermaphroditis : valvulis integris graniferis, foliis lanceolatis undulatis acutis. Syſt. Nat.

CURLED DOCK. In fields. July.

Rumex floribus hermaphroditis : valvulis dentatis nudis, pedicellis planis reflexis. Syſt. Nat.

NARROW DOCK. About barns and in fields. July.

The roots of both theſe ſpecies are ſomewhat cathartic. The ſeeds are ſaid to have been given with great advantage in the dyſentery. The freſh roots bruiſed and made into an ointment, or decoction, cure the itch.

Rumex floribus hermaphroditis : valvulis integerrimis nudis foliis cordatis glabris acutis. Syſt. Nat.

WATER DOCK. In muddy bottom brooks. Not common. July.

The Indians uſed this root with great ſucceſs in cleanſing foul ulcers. It is ſaid they endeavoured to keep it a ſecret from the *Europeans.* Dr. *Withering* ſays, he ſaw an ill-conditioned ulcer in the mouth, which had deſtroyed the palate, cured by waſhing the mouth with a decoction of this root, and drinking a ſmall quantity of the ſame decoction daily.

Not having opportunity to examine this plant ſince Dr. *Withering*'s Botany came into my hands, the circumſtances he mentions, reſpecting the *American* and *Britiſh* ſpecies, have not been particularly attended to. At the time it was examined, it appeared to correſpond with the ſpecific characters of *Linnæus,* which are here given.

Rumex

Rumex floribus dioicis, foliis oblongis sagittatis. Syst. Nat.

SORREL. Common in old fields. June.

MELANTHIUM. Linn. Gen. Plant. 410.

Melanthium petalis unguiculatis. Syst. Nat.

QUAFFIDILLA. Blossoms greenish yellow. In moist ground. Not common. May.

MEDEOLA. Linn. Gen. Plant. 411.

Medeola foliis verticillatis, ramis inermibus. Syst. Nat.

INDIAN CUCUMBER. Blossoms greenish yellow. In rich wood land. June.

The roots, which are of a conic form, are esculent and of an agreeable taste. The Indians made them a part of their food.

POLYGYNIA.

ALISMA. Linn. Gen. Plant. 418.

Alisma foliis ovatis acutis, fructibus obtuse trigonis. Syst. Nat.

WATER PLANTAIN. Blossoms white, with yellow antheræ. In wet places. June.

HEPTANDRIA.

MONOGYNIA.

TRIENTALIS. Linn. Gen. Plant. 419.

Trientalis foliis lanceolatis integerrimis. Syst. Nat.

WINTERGREEN. Blossoms white. Common in wood land. May.

OCTANDRIA.

MONOGYNIA.

RHEXIA. Linn. Gen. Plant. 423.

Rhexia foliis sessilibus serratis. Syst. Nat.

ROBINHOOD.

ROBINHOOD. Leaves hairy. Bloſſoms pale red. In moiſt ground. July—Auguſt.

OENOTHERA. Linn. Gen. Plant. 424.

Oenothera foliis ovato—lanceolatis planis, caule lævi ſubvilloſo. Syſt. Nat.

SUNDROP. Bloſſoms in a kind of ſpike; yellow. They open about eleven o'clock, and, commonly, not more than one on the ſame day. In wet meadows. June.

Oenothera hirta, foliis ſupra glabris. Syſt. Nat.

PRIMROSE. Leaves oblong; ſerrated. Bloſſoms in a large ſpike; terminating; yellow. Common in old fields. July.

This plant is very generally known by the name of *Scabious*, and ſeems to have been miſtaken for the *Scabioſa arvenſis* of *Linnæus*. No ſpecies of *Scabious* has been found native in this part of the country.

EPILOBIUM. Linn. Gen. Plant. 426.

Epilobium foliis ſparſis lineari—lanceolatis. Syſt. Nat.

WILLOWHERB. Stamina erect. Bloſſoms in a long diffuſe ſpike; purple. By fences in moiſt land. July.

Epilobium foliis oppoſitis lanceolatis integerrimis, petalis emarginatis, caule erecto. Syſt. Nat.

MEADOW WILLOWHERB. Bloſſoms reddiſh. Moiſt land. July.

VACCINIUM. Linn. Gen. Plant. 434.

The ſpecies of this genus are generally known, and are too many to admit a particular deſcription in this paper. The following are indigenous.

The

The *Black Whortleberry*. The *Bilberry* or *Blueberry*. Theſe ſhrubs are low when they grow on high land, but tall in ſwamps. The *White Whortleberry*. The *Red Whortleberry*. The fruit of theſe ſpecies are agreeable to children, either eaten by themſelves, or in milk, or in tarts and jellies. The *Choke Whortleberry*. The fruit is unpalatable; but its great degree of aſtringency may, one day or other, recommend it to the attention of phyſicians. The *Craneberry*, or *Moſsberry*. Theſe berries make an agreeable tart. By drying them a little in the ſun, and then putting them in a cloſe veſſel, or ſtopping them up in dry bottles, they may be kept good for many years.

TRIGYNIA.

POLYGONUM. Linn. Gen. Plant. 445.

Polygonum caule ſimpliciſſimo monoſtachyo, foliis ovatis in petiolum decurrentibus. Syſt. Nat.

BISTORT. *Snakeweed*. Bloſſoms red. In wet meadows. Auguſt.

The root is ſaid to be one of the ſtrongeſt vegetable aſtringents.

Polygonum floribus hexandris ſemidigynis, foliis lanceolatis, ſtipulis ſubmuticis. Syſt. Nat.

ARSMART. *Water Pepper*. Bloſſoms white. Common both in dry and moiſt land. Auguſt.

It occaſions ſevere ſmarting when rubbed on the fleſh. The taſte is acrid and burning. It dyes wool yellow. Dr. *Withering* ſays, it cures little aphthous ulcers in the mouth.—That the aſhes mixed with ſoft ſoap is a noſtrum, in a few hands, for diſſolving the ſtone in the bladder; but perhaps not preferable to other cauſtic preparations of the vegetable alkali.

Polygonum

Polygonum floribus hexandris, digynis, spicis ovato-oblongis, foliis lanceolatis, stipulis ciliatis. Syst. Nat.

HEARTSEASE. Spotted Arsmart. The leaves have a dark spot on their upper surface, in form of a crescent. Blossoms reddish white. Common about barns. August.

It will dye woollen cloth yellow, after the cloth has been dipped in a solution of alum.

Polygonum floribus octandris trigynis axillaribus, foliis lanceolatis, caule procumbente herbaceo. Syst. Nat.

KNOTGRASS. Blossoms reddish white. Common by the road sides. June—September.

Polygonum foliis sagittatis, caule aculeato. Syst. Nat.

SICKLEWEED. Bearded Arsmart. Blossoms white, tinged with red. In wet meadows. August.

Polygonum foliis cordatis, caule volubili, floribus planiusculis. Syst. Nat.

BLACK BINDWEED. Wild Bean. Blossoms greenish white. About barns and in corn fields. July—August.

ENNEANDRIA.

MONOGYNIA.

LAURUS. Linn. Gen. Plant. 452.

Laurus foliis enerviis ovatis utrinque acutis integris annuis. Syst. Nat.

FEVER BUSH. Blossoms yellowish. Berries red. Common in moist land. May.

This shrub is aromatic. A decoction of the small twigs makes an agreeable drink in slow fevers, and is much used by the country people. It is said the Indians esteemed it highly for its medicinal virtues.

Laurus

Laurus foliis trilobus integrisque. Syst. Nat.

SASSAFRAS. Blossoms greenish white. Common in loamy land. May.

It is generally a shrub, but sometimes grows into a large tree. The leaves fall early. The bark of the tree is aromatic, and has been substituted by people in the country for spice. It is said, that bedsteads made of this wood, will never be infested with bugs. It is said to be an excellent diuretic and diaphoretic, and therefore efficacious in obstructions of the viscera, cachexies, scorbutic complaints and in the venereal disease. An infusion of the bark of the roots makes a grateful drink. A very pungent, hot oil is extracted from it, which is said to possess most of the virtues of the wood. It has been exported in considerable quantities to *Europe*.

DECANDRIA.

MONOGYNIA.

PANTHEON. American *Senna.* The *Calix*, if properly any, a narrow husky border. *Corolla* three petals standing in a papilionaceous form. *Vexillum* very large ; erect ; slightly divided into three segments. *Alæ* narrow ; obtuse ; as long as the vexillum. *Carina* none. *Stamina* ten filaments ; erect ; separate ; longer than the corolla. *Antheræ* orbicular. *Germen* ovate ; hairy. *Stile* cylindrical ; longer than the stamina. *Stigma* capitate ; sending off several long hairs. *Capsule* ovate ; five valves ; five cells. Seeds many ; small.

It is a small shrub. Leaves spear-shaped, and do not commonly appear until the shrub is in full bloom. Blossoms in tufts at the termination of the branches ; bluish purple, cloud-

ed with dark red. It makes an elegant appearance amongſt flowering ſhrubs in gardens. On the declivity of hills near ſwamps. May.

MONOTROPA. Linn. Gen. Plant. 477.

Monotropa caule unifloro, flore decandro. Syſt. Nat.

BIRDSNEST. Bloſſoms yellow. About *Great Oſſapy* pond, in the ſtate of *New-Hampſhire.* July.

JUSSIÆA. Linn. Gen. Plant. 478.

WOOD PLANTAIN. *Rattle-Snake Plantain.* The germen within the corolla. The other characters agree with *Linnæus's* deſcription. The ſtems are erect, with only one or two ſmall leaves; five petals in the flowers. Radical leaves large; ovate; ſlightly indented; ſpreading on the ground. Bloſſoms in open ſpikes; terminating; greeniſh white. In rich wood land. June.

It is ſaid to cure the bite of a rattle-ſnake, by applying the chewed leaves to the wound, and ſwallowing a quantity of the juice. It commonly grows plentifully near their dens. Where-ever theſe dangerous ſerpents haunt, nature ſeems to have provided an effectual antidote againſt their venom.

KALMIA. Linn. Gen. Plant. 482.

Kalmia foliis ovatis, corymbis terminalibus. Syſt. Nat.

GREAT LAUREL. *Wintergreen.* *Spoonhaunch.* Bloſſoms white, tinged with red. In moiſt, rocky paſtures. June—July.

The Indians are ſaid to have made ſmall diſhes, ſpoons, and other utenſils, out of the roots. They are ſometimes employed by people in the country for ſimilar purpoſes. They are large, of

of a ſoft texture, and eaſily wrought when green; but when thoroughly dry, become very hard and ſmooth. Under cultivation it makes a moſt beautiful flowering ſhrub.

Kalmia foliis lanceolatis, corymbis lateralibus. Syſt. Nat.

WINTERGREEN. Dwarf Laurel. Ivy. Lambkill. It is an ever-green. Bloſſoms variegated. Common in cold, wet land. June—July.

If the leaves are eaten by ſheep, they prove fatal. Some have ſuppoſed, it is not owing to any poiſonous, but an indigeſtive quality in the leaves, occaſioned by the large quantity of reſin they contain. Others ſay, that, in many inſtances, none of the leaves are found in the ſtomach, but evident marks of coroſive poiſon. It makes an elegant appearance, properly diſpoſed amongſt other flowering ſhrubs, in a border. But its being ſo common, and the diſadvantage it uſually appears under in a wild ſtate, have prevented its being introduced into gardens.

ANDROMEDA. Linn. Gen. Plant. 485.

Andromeda racemis ſecundis nudis, corollis rotundo-ovatis. Syſt. Nat.

WHITE PEPPERBUSH. Bloſſoms white. Common in ſwamps. June.

It is generally called *Oſier*, which is the *Engliſh* name of the *Salix viminalis* of *Linnæus*, one of the ſpecies of the *Willow*. It is uſed for fiſh-flakes, and, as the wood is very hard and durable, is one of the beſt ſhrubs employed for that purpoſe.

Andromeda.

GARDROBE. Bog Ever-green. Fruit-ſtalks ſingle; in the *axillæ* of the leaves. Corolla ovate. Leaves lanceolate; alternate.

ternate. Bloſſoms pendent; white. Common in fens and quagmires. April—May.

ARBUTUS. Linn. Gen. Plant. 488.

Arbutus caule erecto, foliis glabris integerrimis, baccis polyſpermis. Syſt. Nat.

FOXBERRY. Checkerberry. Bloſſoms white. Berries red. Common in pine and ſhrub oak land. It blooms in July and Auguſt, but the fruit is not ripe until the next ſpring.

It is in a very ſmall degree aromatic. The leaves are much celebrated by the common people as a diuretic and ſweetner of the blood, but are of very little efficacy. It makes an ingredient in their diet-drinks. The berries are rather of an agreeable taſte, and are ſometimes eaten by children in milk.

CLETHRA. Linn. Gen. Plant. 489.

SWEET PEPPERBUSH. A ſhrub. Leaves inverſely ovate; ſerrated. Bloſſoms in long ſpikes; terminating; white. Common in moiſt land and ſwamps. July—Auguſt.

PYROLA. Linn. Gen. Plant. 490.

Pyrola ſtaminibus adſcendentibus, piſtillo declinato. Syſt. Nat.

CONSUMPTION-ROOT. Bloſſoms white. In wood land. July.

Pyrola floribus racemoſis diſperſis, ſtaminibus piſtilliſque rectis. Syſt. Nat.

RHEUMATISM-WEED. Bloſſoms pale red. In wood land. It abounds near *White-Mountains.*

It is ſaid to have been conſidered by the Indians as an effectual remedy in rheumatiſms.

FALSEVINE.

FALSEVINE. The *calix* is a permanent perianthium of one leaf; bell-ſhaped. Limb divided into ten ſmall, unequal, erect ſegments. *Corolla* five narrow, patent petals; inſerted into the mouth of the cup. *Stamina* ten ſubulated filaments; longer than the corolla. *Antheræ* oblong. *Germen* above; globular. *Stile* cylindrical; ſhorter than the cup. *Stigma* capitate and jagged. Capſule globular; three cells; three valves. Seeds many; ſmall; ovate.

The ſtem is angular; reclining. If the end touches the ground it takes root. Leaves ſpear-ſhaped; entire. Bloſſoms on ſhort flower-ſtalks riſing from the *axillæ* of the leaves; deep purple. In wet meadows, and on the borders of ponds and rivers. July.

This plant, if it be eaten in large quantities, will occaſion abortion in all kinds of herbivorous animals. It is frequently mowed with meadow-graſs, and ſeems to be grateful food in the winter to all ſorts of cattle. But in ſome inſtance it has deprived farmers of almoſt all the increaſe of their ſtock in the ſpring. Thoſe who are acquainted with its baneful effects, are careful to ſeparate it from their hay, when they rake it.

DIGYNIA.

SAXIFRAGA. Linn. Gen. Plant. 494.

Saxifraga foliis lanceolatis denticulatis, caule nudo paniculato, floribus ſubcapitatis. Syſt. Nat.

GOLDEN SAXIFRAGE. Bloſſoms rediſh.

TRIGYNIA.

CUCUBALUS. Linn. Gen. Plant. 502.

Cucubalus calycibus ſubglobosis glabris reticulato-venoſis, capſulis trilocularibus, corollis ſubnudis. Syſt. Nat.

CAMPION.

CAMPION. *Bladder Behen.* *Bellweed.* Bloſſoms white. On borders of fields in *Lynn.* July.

STELLARIA. Linn. Gen. Plant. 504.

Stellaria foliis linearibus integerrimis, floribus paniculatis. Syſt. Nat.

STITCHWORT. Bloſſoms in panicles ; white. Amongſt buſhes. May.

ARENARIA. Linn. Gen. Plant. 505.

Arenaria foliis filiformibus, ſtipulis membranaceis vaginantibus. Syſt. Nat.

SANDWORT. Bloſſoms rediſh white. On the ſea ſhore. Auguſt.

Arenaria foliis ovatis nervoſis ſeſſilibus acutis. Syſt. Nat.

SPURRY. Bloſſoms white. In wood land. July.

PENTAGYNIA.

OXALIS. Linn. Gen. Plant. 515.

Oxalis ſcapo unifloro, foliis ternatis, radice ſquamoſa articulata. Syſt. Nat.

WOOD SORREL. *Cuckow-Bread.* *Sour Trefoil.* In rainy weather the leaves ſtand upright, but in dry weather they hang down. Bloſſoms yellow. In ſhady places. May—Auguſt.

Dr. *Withering* ſays, the expreſſed juice depurated properly evaporated, and ſet in a cool place, affords a chryſtalline acid ſalt in conſiderable quantity, which may be uſed wherever vegetable acids are wanted. The *London* College directs a conſerve to be made with the leaves beaten with thrice their weight of fine ſugar. The juice is gratefully acid. An infuſion of the leaves is an agreeable liquor in ardent fevers.

SPERGULA.

SPERGULA. Linn. Gen. Plant. 319.

Spergula foliis verticillatis, floribus pentandris. Syst. Nat.

PINEY. *Spurry.* Blossoms white. In cultivated ground, especially among flax. August.

DECAGYNIA.

PHYTOLACCA. Linn. Gen. Plant. 521.

Phytolacca floribus decandris. Syst. Nat.

GARGET. *Cunicum.* *Skoke.* American *Nightshade.* Blossoms white, tinged with red. Berries black. Common by road sides. July.

The juice of the berries gives a fine purple tincture to paper, but it soon fades. The berries are employed in dyes by the country people, but the colours are not lasting. They would make a most beautiful purple dye, if some method could be found for fixing the colour. The roots are emetic and cathartic. An ounce of the dried root, infused in a pint of wine, and given to the quantity of two spoonfuls, frequently operates very kindly as an emetic. In some cases it is preferable to most other emetics, as it hardly alters the taste of the wine. The roots are applied to the hands and feet in ardent fevers. Farriers give a decoction of them to drench cattle, and apply them, in form of poultice, for discussing tumors. The young shoots boiled, are hardly to be distinguished from spinach, and are nutritious and wholesome. Poultry are fond of the berries; but, if eaten in large quantities, will give their flesh a disagreeable flavour.

DODECANDRIA.

MONOGYNIA.

PORTULACA. Linn. Gen. Plant. 531.

Portulaca foliis cuneiformibus floribus sessilibus. Syst. Nat.

PURSLANE. The number of the stamina are inconstant. Blossoms yellow. In corn-fields. July. It

It is eaten as a pot-herb, and eſteemed by ſome as little inferior to aſparagus.

LYTHRUM. Linn. Gen. Plant. 532.

Lythrum foliis alternis linearibus, floribus hexandris. Syſt. Nat.

WILD HYSSOP. *Graſſpoly.* Bloſſoms purple. In wet land. June—July.

DIGYNIA.

AGRIMONIA. Linn. Gen. Plant. 534.

Agrimonia foliis caulinis pinnatis : foliolis undique ſerratis : omnibus minutes interſtinctis, fructibus hiſpidis. Syſt. Nat.

AGRIMONY. The number of ſtamina from five to twelve. Bloſſoms on long terminating ſpikes ; yellow. By fences. July.

It is ſaid the Indians uſed an infuſion of the roots in inflammatory fevers, with great ſucceſs. Dr. *Hill* ſays, an infuſion of ſix ounces of the crown of the root in a quart of boiling water, ſweetened with honey, and half a pint of it drank three times a day, is an effectual cure for the jaundice. He adviſes to begin with a vomit, afterwards to keep the bowels ſoluble, and to continue the medicine as long as any ſymptoms of the diſeaſe remains.

ICOSANDRIA.

MONOGYNIA.

PRUNUS. Linn. Gen. Plant. 546.

Specific deſcriptions under this genus, as well as that of the *Vaccinium*, are, for the ſame reaſons, omitted. The trees and ſhrubs found growing naturally, are known by the following names.

The

The *Beach*, or *Sea-Side Plumb*. There are ſeveral varieties of this ſpecies growing plentifully on *Plumb-Iſland*. The fruit of ſome of them, when fully ripe, is well-taſted. They are eaſily propagated in gardens, by planting the ſtones in a mixture of beach ſand and loam, and will produce fruit in two or three years.

The *Black Cherry Tree*. It is common, grows large, and the wood, which is ſmooth and hard, is uſed by cabinet-makers in many kinds of work. They have the art of giving it a ſtain which approaches the colour of mahogany. The fruit is rather indifferent in its natural ſtate, but might probably be greatly improved by cultivation. It is infuſed in rum and brandy for the ſake of giving them an agreeable flavour. An infuſion or tincture of the inner bark is given with ſucceſs in the jaundice. The *Small Black Cherry*. The tree is ſmall and ſhrubby, and the fruit not ſo well flavoured as the large black cherry. The *Black Choke Cherry*. A low ſhrub. The *Large Red Cherry*. A ſmall tree. The *Dwarf Red Cherry*, A very low ſhurb. The *Red Choke Cherry*. A ſhrub. The *Small Pale Red Cherry*. A ſmall tree, and the fruit hard and ill-taſted.

The laſt-mentioned cherry tree abounds, where land has been cleared, in the new plantations near *White-Mountains*, but is rarely, if at all, found in the foreſts. Some have aſſerted, that this ſpecies of cherry tree is not found in that part of the country, except in places where the native growth has been deſtroyed. In land, where there is no kind of cherry trees after the old growth, which conſiſts chiefly of ſpruce, pine, beach and birch, (exceedingly tall and large) has been fell and burnt on the ground, there ſprings up, the next ſummer, an immenſe

 number

number of these cherry trees. By what means are they produced? The doctrine of equivocal, or spontaneous generation, has long been exploded. Nature has not formed the seeds for being wafted by the wind. Can it be supposed such vast numbers were scattered by birds? Or, upon this supposition, is there not difficulty in conceiving, that neither the long period of time which most of them must be supposed to have laid in the ground, nor the intense heat, occasioned by burning such prodigious piles of wood, should destroy their vegetive quality?

DIGYNIA.

CRATÆGUS. Linn. Gen. Plant. 547.

Cratægus foliis cordatis repando-angulatis serratis glabris. Syst. Nat.

HAWTHORN. Blossoms white. Fruit red. In dry land. May. It is said that an ardent spirit may be distilled from the fruit.

Cratægus foliis lanceolato-ovatis serratis glabris, ramis spinosis. Syst. Nat.

THORNBUSH. Blossoms white. Fruit red. Common in hedges. May.

PENTAGYNIA.

PYRUS. Linn. Gen. Plant. 550.

Pyrus foliis serratis, floribus corymbosis. Syst. Nat.

BASTARD PEAR. *Juniper.* A shrub which blooms very early in the spring, commonly before other trees are leaved out. Blossoms white. The fruit is redish, small, nearly round, and well tasted. It ripens in June; but birds are so fond of it that they rarely suffer it to remain until it is ripe. It is eaten by children in milk. Common in moist land.

SPIRÆA. Linn. Gen. Plant. 554.

Spiræa foliis lanceolatis obtusis serratis nudis, floribus duplicato-racemosis. Syst. Nat.

MEADOW

MEADOW SWEET. Bloſſoms white, tinged with red. In moiſt paſtures. Auguſt.

Spiræa foliis lanceolatis inæqualiter ſerratis ſubtus tomentoſis, floribus duplicato-racemoſis. Syſt. Nat.

QUEEN OF THE MEADOWS. Bloſſoms red or purple. In moiſt paſtures. July—Auguſt.

POLOGYNIA.

ROSA. Linn. Gen. Plant. 556.

Roſa germinibus globoſis hiſpidis, pedunculis ſubhiſpidis, caule aculeis ſtipularibus, petiolis aculeatis. Syſt. Nat.

WILD ROSE. Dog Roſe. Bloſſoms red. Berry pale red. Common in moiſt land. June.

The bloſſoms gathered before they expand, and dried, are aſtringent; but when full blown, are purgative. This ſpecies is generally preferred for conſerves. A perfumed water may be diſtilled from the bloſſoms. The pulp of the berries, beat up with ſugar, makes the conſerve of hepps of the *London* diſpenſatory. The dried leaves of every ſpecies of roſe have been recommended as a ſuſtitute for *India* tea, giving out a fine colour, a ſub-aſtringent taſte, and a grateful ſmell.

RUBUS. Linn. Gen. Plant. 577.

Rubus foliis quinato-pinnatis ternatiſque, caule aculeato, petiolis canaliculatis. Syſt. Nat.

RASPBERRY. Bloſſoms white. Berry pale red. Common by ſtone walls. June.

The fruit is ſub-acid, cooling and extremely grateful. If it be made into ſweet-meat, with ſugar, or formented with wine, the flavour is improved. It is eaten in milk, and with cream and ſugar. Dr. *Withering* ſays, it diſſolves the tartarous con-

cretions of the teeth ; but for this purpofe it is inferior to the ftrawberry.

Rubus foliis ternis fubtus tomentofis, caule aculeato, petiolis teretibus. Syft. Nat.

BRAMBLE. *Upright Brier.* Bloffoms white. Berry dark brown. In hedges. June.

Rubus foliis ternatis fubnudis : lateralibus bilobis, caule aculeato tereti. Syft. Nat.

SMALL BRAMBLE. *Blackberry Brier. Dewberry.* Bloffoms white. Berry black. Common in old fields. June.

Rubus foliis quinato-digitatis ternatifque, caule petiolifque aculeatis. Syft. Nat.

SOWTEAT. *Bumblekites.* Bloffoms white. Berries black. In hedges, and by fences. May—June.

The fruit is pleafant to eat, and communicates a fine flavour to red wine. It is frequently infufed in brandy and rum. The green twigs are faid to be of great ufe in dying woollen, filk and mohair black.

Rubus foliis digitatis denis quinis ternatifque, caule inermi. Syft. Nat.

SUPERB RASPBERRY. Bloffoms large ; in panicles ; petals purple ; antheræ yellow. Berry redifh yellow. In high land on the declivity of hills. It grows plentifully in the new-plantations at the northward. June—September.

The fruit is much larger and more delicious than the common rafpberry. It is eafily cultivated in gardens ; and the large fize of the leaves and bloffoms give it an elegant appearance. Ripe fruit and bloffoms are commonly found on the fame panicles.

Rubus

Rubus foliis ſimplicibus cordatis lobatis, caule aculeato decumbente. Syſt. Nat.

BLACKBERRY. Bloſſoms white. Berry black. Common in old fields. May.

The fruit is well taſted. Children are fond of them in milk. They are infuſed in rum and brandy, and give them a flavour little inferior to that of black cherries.

FRAGARIA. Linn. Gen. Plant. 558.

Fragaria flagellis reptans. Syſt. Nat.

STRAWBERRY. Bloſſoms white. Berry red. In fields and paſtures. May.

The fruit in its uncultivated ſtate, if the ſoil be rich, is large and well taſted, but may be greatly improved by culture. The white fruited, double flowering, and other varieties, are produced by cultivation. It is ſub-acid, cooling, and may be eaten in large quantities without offending the ſtomach. Dr. *Withering* ſays, they promote perſpiration, impart a violet ſmell to the urine, and diſſolve the tartarous incruſtations upon the teeth. People afflicted with the ſtone or gout have found great relief by uſing them very freely. *Hoffman* ſays, he has known conſumptive people cured by them. They are univerſally eſteemed a moſt delicious fruit, either eaten alone, or with ſugar or milk.

POTENTILLA. Linn. Gen. Plant. 559.

Potentilla foliis pinnatis ſerratis, caule repente. Syſt. Nat.

MARSH TANSEY. Silverweed. Bloſſoms yellow. Borders of marſhes. June.

Potentilla foliis quinatis, caule repente, pedunculis unifloris. Syſt. Nat.

CINQUEFOIL.

CINQUEFOIL. Fivefinger. Bloſſoms yellow. In old fields. June.

It is mildly aſtringent and antiſeptic. A decoction of it is uſed as a gargle for looſe teeth and ſpungy gums.

GEUM. Linn. Gen. Plant. 561.

Geum floribus erectis, fructu globoſo : ariſtis uncinatis nudis, foliis ternatis. Syſt. Nat.

BENNET. Common Avens. Herb-Bennet. Bloſſoms white or yellow. By fences and borders of fields. July.

Dr. *Withering* ſays, the roots gathered in the ſpring, before the ſtem grows up, and put into ale, give it a pleaſant flavour, and prevent its growing ſour. Infuſed in wine it is a good ſtomachic. When it grows in warm dry ſituations, its taſte is mildly auſtere and aromatic.

Geum floribus nutantibus, fructu oblongo : ariſtis plumoſis. Syſt. Nat.

WATER AVENS. Throatroot. Cureall. Bloſſoms purpliſh. In boggy meadows. May.

The root is powerfully aſtringent. A decoction of it has been uſed, with good ſucceſs, as a gargle, and a drink, in inflammed and ulcerated ſore throats, and cankers. It is ſaid, that the powdered root will cure tertian agues, and that it is much uſed by the *Canadians* for that purpoſe.

POLYANDRIA.

MONOGYNIA.

ACTÆA. Linn. Gen. Plant. 568.

Actæa racemo ovato, fructibus baccatis. Syſt. Nat.

CHRISTOPHER. Baneberries. Bloſſoms white. Berry red. In wood land and ſhady places. May.

The

The berries are exceedingly poisonous. Dr. *Withering* says, the plant is powerfully repellant; and that the root is useful in some nervous cases, but it must be administered with caution. It is said, that toads, allured by the fœtid smell of this plant, resort to it.

SANGUINARIA. Linn. Gen. Plant.

BLOODROOT. Puccoon. Leaves roundish; deeply indented. Stems naked; supporting single flowers. Blossoms white. In rich wood land. April.

When the fresh root is broken, a juice issues, in large drops, resembling blood. The Indians used it for painting themselves, and highly esteemed it for its medical virtues. It is emetic and cathartic, but must be given with caution. An infusion of the root in rum or brandy makes a good bitter. If it be planted in rich shady borders, it flourishes well in gardens; and the large leaves and blossoms make an agreeable appearance soon after the frost is out of the ground.

CHELIDONIUM. Linn. Gen. Plant. 572.

Chelidonium pedunculis umbellatis. Syst. Nat.

CELANDINE. Blossoms yellow. Common by fences and amongst rubbish. June—August.

This plant is very acrimonious. The juice destroys warts, and cures ringworms. Diluted with milk, it is said to consume white opake spots upon the eyes.

SARRACENIA. Linn. Gen. Plant. 578.

Sarracenia foliis gibbis. Syst. Nat.

SARRACENE. Side-Saddle Flower. Hallow-leaved Plant. The leaves are tubular, somewhat resembling the horn of an ox inverted. The aperture at the top is horizontal and circular, with

with a broad patent, foliaceous appendage, extending two-thirds of the way round it. A ſimilar appendage runs down the concave ſide to the root. The cavities of the leaves are large, and generally contain a quantity of water. They ſeem to be deſigned by nature for reſervoirs, from which the plants may be conſtantly ſupplied with moiſture. The ſtems are erect and naked. Bloſſoms ſingle, terminating and reclining; petals red; the ſtigma, which covers the diſk, rediſh green. In moiſt land, eſpecially in fens and quagmires. May—June.

NYMPHÆA. Linn. Gen. Plant. 579.

Nymphæa calyce magno pentaphyllo. Syſt. Nat.

WATER YELLOW LILY. *Toad Lily.* Bloſſoms yellow. In ponds and rivers. June.

Nymphæa foliis cordatis integerrimis, calyce quadrifido. Syſt. Nat.

POND LILY. *Water Lily.* Bloſſoms white. In ponds and rivers. July.

The flowers open about ſeven in the morning, and cloſe about four in the afternoon. A conſerve is made of the leaves of the bloſſoms. The roots of both ſpecies are much uſed, in form of poultices, for producing ſuppuration in boils and painful tumors, and are very efficacious. The root of the water yellow lily is generally preferred. Dr. *Withering* ſays, the roots of the pond lily are uſed in *Ireland,* and in the iſland of *Jura,* to dye a dark brown.

BIXA. Linn. Gen. Plant. 581.

BASS WOOD. *White Wood.* *Suggumug.* The ſtigma is quadrifid. Bloſſoms white. In woods. Not common. July.

This

This tree is of a middling ſize, and the wood very white and ſoft. When it is perfectly dry it ſwims on the water like cork. It is uſed by turners for making bowls, trenchers and diſhes.

CISTUS. Linn. Gen. Plant. 598.

Ciſtus herbaceus exſtipulatus, foliis omnibus alternis lanceolatis, caule adſcendente. Syſt. Nat.

AMERICAN CISTUS. Little Sunflower. Bloſſoms yellow, and the diſk commonly turned towards the ſun from morning until night. In dry paſtures. June.

PENTAGYNIA.

AQUILEGIA. Linn. Gen. Plant. 605.

Aquilegia nectariis rectis, ſtaminibus corolla longioribus. Syſt. Nat.

COLUMBINE. Honey Horns. Bloſſoms red. Amongſt rocks in dry land. May.

Cultivation renders it equal in beauty to any of the exotic columbines. It makes an elegant appearance among them, and adds to the variety in flower-borders.

NIGELLA ? Linn. Gen. Plant. 606.

GOLDENTHREAD. Mouth Root. The number of *petals* from five to ſeven ; commonly ſix. *Nectaria* ſix cups ; ſupported on filament nearly as long as the ſtamina. *Germina* from three to ſeven ; commonly ſix.

The roots thread-ſhaped ; running ; bright yellow. Leaves grow by threes ; circular ; ſcolloped. Stems erect ; naked. Bloſſoms ſolitary ; terminating ; white. Common in ſwamps. May.

The roots are aſtringent, and of a bitteriſh taſte. Chewed in the mouth they cure apthas and cankerous ſores. It is frequently an ingredient in gargles for ſore throats.

POLYGYNIA.

ANEMONE. Linn. Gen. Plant. 614.

Anemone foliis trilobis integerrimis. Syſt. Nat.

LIVERWORT. Bloſſoms white, tinged with red. In woods and ſhady places. April.

Anemone pedunculo nudo, ſeminibus ſubrotundis hirſutis. Syſt. Nat.

WHITE ANEMONE. Bloſſoms white. Amongſt buſhes, and in ſhady places. May.

Anemone ſeminibus acutis, foliolis inciſis, caule unifloro. Syſt. Nat.

WOOD ANEMONE. Bloſſoms white, tinged with purple. In woods and newly-cleared land. May.

CLEMATIS. Linn. Gen. Plant. 616.

Clematis foliis ternatis, foliolis cordatis ſerrato-angulatis, ſcandentibus. Syſt. Nat.

TRAVELLER's JOY. Virgin's Bower. Bloſſoms white. Banks of brooks and river's. July.

RANUNCULUS. Linn. Gen. Plant. 619.

Ranunculus foliis radicalibus reniformibus crenatis ſublobatis, caulinis tripartitis lanceolotis integerrimis, caule multifloro. Syſt. Nat.

PILEWORT. Burwort. Bloſſoms yellow. By fences. September.

Ranunculus foliis radicalibus ſubrotundo-cordatis crenatis; caulinus digitatis dentatis, caule multifloro. Syſt. Nat.

CROWFOOT. Buttercup. Goldilocks. Bloſſoms yellow. Common in moiſt paſtures and fields. June—July.

The whole plant is acrid. The bloſſoms cure warts and corns.

CALTHA.

CALTHA. Linn. Gen. Plant. 623.

MEADOW-BOUTS. Cowslips. Marsh Marigold. Stems branched. Leaves kidney-shaped. Blossoms yellow. In brooks and watery places. April—May.

Many people esteem it a good pot-herb. Dr. *Withering* says, the flowers gathered, and preserved in salted vinegar, are a good substitute for capers. The juice of the flowers boiled, with the addition of alum, stains paper yellow. It has been supposed, that the remarkable yellowness of butter in the spring, is caused by this plant: but *Boerhaave* says, if cows eat it, it will occasion such inflammation, that they generally die.

DIDYNAMIA.

GYMNOSPERMIA.

TEUCRIUM. Linn. Gen. Plant. 625.

Teucrium foliis ovatis inæqualiter serratis, racemis terminalibus. Syst. Nat.

GERMANDER. Wood Sage. Blossoms white, tinged with red. Near *Dummer* Academy. Not common. July.

NEPETA. Linn. Gen. Plant. 629.

Nepeta floribus spicatis: verticillis subpedicellatis, foliis petiolatis cordatis dentato-serratis. Syst. Nat.

CATMINT. Catnip. Blossoms pale purple, or blue. About barns and fields. July.

An infusion of the plant, especially of the blossoms, is grateful to the stomach, and a mild carminative, but of no great efficacy. Dr. *Withering* says, an infusion of it is deemed a specific in chlorotic cases. It is much used by the country people here in the same cases. Cats are remarkably fond of this plant. Mr. *Miller* says, they eat it until it produces a kind of drunkenness, and then tear it to pieces with their claws.

BETONICA. Linn. Gen. Plant. 631.

Betonica ſpica interrupta, corollaram lacinia labii intermedia emerginata? Syſt. Nat.

HEAD BETONY. The middle ſegment of the lower lip of the bloſſom is toothed. Bloſſoms purple. Woods and fields. July —Auguſt.

Dr. *Withering* ſays, the freſh leaves intoxicate, and the dry leaves excite ſneezing;—that it is ſmoked as tobacco; and that the roots provoke vomiting.

MENTHA. Linn. Gen. Plant. 633.

Mentha floribus ſpicatis, foliis oblongis ſerratis.

HORSE MINT. Bloſſoms blue. By brooks, and in wet meadows. July.

Mentha ſpicis ſolitaris interruptis, foliis lanceolatis ſerratis ſeſſilibus. Syſt. Nat.

SPEAR MINT. Bloſſoms purpliſh red. In moiſt ground. Auguſt.

It has a more agreeable flavour than the Horſe Mint, and is preferred for culinary and medical purpoſes. The juice of the leaves, boiled up with ſugar, is formed into tablets. The leaves make an agreeable conſerve. The diſtilled waters, both ſimple and ſpiritous, are generally eſteemed pleaſant. The eſſential oil and diſtilled waters are conſidered as carminative. They are given with ſucceſs for removing ſickneſs at the ſtomach.

Mentha floribus capitatis, foliis ovatis ſerratis petiolatis, ſtaminibus corolla longioribus. Syſt. Nat.

WATER MINT. Bloſſoms pale red. By brooks and rivers. Auguſt.

Mentha

Mentha floribus verticillatis, foliis ovatis obtusis suberenatis caulebus subteretibus repentibus. Syst. Nat.

PENNYROYAL. Stamina pale purple. In pastures and fields. July—September.

The expressed juice, with sugar, is given in the hooping cough. An infusion of the plant and the distilled water are antispasmodic, and are prescribed in hysterical cases.

GLECOMA. Linn. Gen. Plant. 634.

Glecoma foliis reniformibus crenatis. Syst. Nat.

GROUND IVY. *Gill-go-over-the-Ground. Robin-run-away.*

A decoction of the leaves is esteemed by the common people a remedy for the jaundice. Dr. *Withering* says, the leaves are thrown into the vat with ale, to clarify it, and give it a flavour: and that ale thus prepared, is often drank as an antiscorbutic. The expressed juice mixed with wine, and applied morning and evening, it is said, will destroy white specks upon horses eyes. The plant is also said to be hurtful to horses, if they eat it in large quantities.

GALEOPSIS. Linn. Gen. Plant. 637.

Galeopsis internodiis caulinis superne incrassatis, verticillis summis subcontiguis. Syst. Nat.

ALLHEAL. *Hemp-leaved Dead-Nettle.* Blossoms purple. By the road side. *Gloucester.* August.

STACHYS. Linn. Gen. Plant. 638.

Stachys verticillis sexfloris, foliis cordatis petiolatis. Syst. Nat.

CLOWNHEAL. *Hedge Nettle.* Blossoms purple, spotted with white. By fences and amongst bushes. July—August.

It has a fœtid smell, and toads are thought to be fond of living under its shade. It will dye yellow.

MARRUBIUM.

MARRUBIUM. Linn. Gen. Plant. 640.

Marrubium dentibus calycinis ſetaceis uncinatis. Syſt. Nat.

HOREHOUND. Bloſſoms white. By road ſides, and among rubbiſh. July.

Dr. *Withering* obſerves, that it was a favourite medicine with the ancients in obſtructions of the viſcera.—In large doſes it looſens the belly. He ſays, that it is the principal ingredient in the Negro *Cæſar's* remedy for vegetable poiſons.—That a young man, who had occaſion to take mercurial medicine, was thrown into a ſalivation, which continued for more than a year. Every method that was tried to remove it, rather increaſed the complaint. At length *Linnæus* preſcribed an infuſion of this plant, and the patient got well in a ſhort time.

LEONURUS. Linn. Gen. Plant. 641.

Leonurus foliis caulinis lanceolatis trilobis. Syſt. Nat.

MOTHERWORT. Bloſſoms purpliſh. Among rubbiſh. July —Auguſt.

Leonurus foliis ovatis lanceolatiſque ſerratis, calycibus ſeſſilibus ſpinoſis. Syſt. Nat.

MARRUBY. Lion's Tail. Bloſſoms rediſh. By fences in moiſt land. Not common. July.

ORIGANUM. Linn. Gen. Plant. 645.

Origanum ſpicis ſubrotundis paniculatis conglomeratis, bracteis calyce longioribus ovatis. Syſt. Nat.

WILD MARJORAM. Bloſſoms purple. Amongſt brambles by fences. July.

It is warm and aromatic. Dr. *Withering* ſays, the eſſential oil is ſo acrid that it may be conſidered as a cauſtic, and is much uſed with that intention by farriers. A little cotton wool moiſtened

ened with it, and put into the hollow of an aching tooth, frequently relieves the pain. The dried leaves make an exceedingly grateful tea. The tops of the plant dye purple.

DRACOCEPHALUM. Linn. Gen. Plant. 648.

Dracocephalum floribus ſpicatis, foliis lanceolatis ſerratis. Syſt. Nat.

DRAGON's HEAD. The middle ſegment of the *lower lip* the largeſt ; intire. Bloſſoms variegated with red and white. By ſtone walls in *Dedham.* July.

TRICHOSTEMA ? Linn. Gen. Plant. 652.

Trichoſtema ſtaminibus longiſſimis exertis. Syſt. Nat.

WILD LAVENDER. Great Pennyroyal. The *upper lip* divided into two erect ſegments ; compreſſed. The lateral ſegments of the *lower lip* erect ; nearly ſimilar to the ſegments of the upper lip ; middle ſegment larger ; club-ſhaped ; convex ; reflected. *Stigma* bifid ; reflected. Bloſſoms ſolitary ; terminating ; purple. In old fields. Auguſt—September.

SCUTELLARIA. Linn. Gen. Plant. 653.

Scutellaria foliis ſeſſilibus ovatis : inferioribus obſolete ſerratis ; ſuperioribus integerrimis. Syſt. Nat.

HOODWORT. Bloſſoms blue. By fences in *Sandwich.* Aug.

Scutellaria foliis cordato-oblongis acuminatis ſerratis, ſpicis ſubnudis. Syſt. Nat.

TALL HOODWORT. Bloſſoms pale blue. In open wood land in *Weymouth.* Auguſt.

ANGIOSPERMIA.

EUPHRASIA. Linn. Gen. Plant. 659.

Euphraſia foliis linearibus ſerratis : ſuperioribus integerrimis. Syſt. Nat.

EYEBRIGHT.

EYEBRIGHT. Mouthwort. Bloſſoms blue. Amongſt low buſhes. July.

It has been in repute for recovering impaired eye-ſight.

MELAMPYRUM. Linn. Gen. Plant.

Melampyrum corollis hiantibus. Syſt. Nat.

COW-WHEAT. Bloſſoms yellowiſh white. In woods. June.

CHELONE. Linn. Gen. Plant. 666.

Chelone foliis lanceolatis ſerratis : ſummis oppoſitis. Syſt. Nat.

CHELONE. Fiſh-head. Snake-head. Bloſſoms in ſpikes ; white. Common by fences and amongſt buſhes in moiſt land. Auguſt.

ANTIRRHINUM. Linn. Gen. Plant. 668.

Antirrhinum foliis lanceolatis obtuſis alternis, caule ramoſiſſimo diffuſo. Syſt. Nat.

TOAD-FLAX. Bloſſoms purple. In fields and road ſides. June—Auguſt.

Antirrhinum foliis linearibus alternis, corollis hiantibus : labio inferiore explanato. Syſt. Nat.

SNAP-DRAGON. Fluellin. Bloſſoms yellow, with a mixture of ſcarlet. Common by road ſides in *Lynn* and *Cambridge*. June—July.

The ſeed of a ſpecies of the Antirrhinum, nearly reſembling this plant, and not at all ſuperior in beauty, is imported by our ſeed-ſellers, and is common in curious flower-gardens.

SCROPHULARIA. Linn. Gen. Plant. 674.

Scrophularia foliis cordatis ſerratis acutis baſi rotundatis, caule obtuſangulo. Syſt. Nat.

FIGWORT. Bloſſoms purpliſh, with a ſmall ſegment, reſembling a lip, in their mouths. By fences in wet land. Aug.

The

The plant has a rank ſmell and bitter taſte. It is ſaid, that ſwine that have the ſcab are cured by waſhing them with a decoction of the leaves.

DIGITATIS. Linn. Gen. Plant. 676.

Digitatis calycinis foliolis ovatis acutis, corollis obtuſis : labio ſuperiore integro. Syſt. Nat.

FOX-GLOVE. Hornwort. Bloſſoms red. In moiſt land. Aug.

This is another plant which has been miſtaken for *Paul's Betony*, a ſpecies of the *Veronica.*

BIGNONIA. Linn. Gen. Plant. 677.

TRUMPET-FLOWER. Yellow Jaſmine. Stems round ; erect. Leaves lanceolate ; oppoſite ; irregularly ſerrated. Bloſſoms ſolitary ; on ſhort flower-ſtalks riſing from the *axillæ* of the leaves ; yellow. On the borders of fields, and in open woods. July.

This plant has alſo been called *Paul's Betony.*

WOOD BETONY. The *calix* a perianthium of one leaf ; tubular. Border entire ; ſloped. *Corolla* one petal ; gaping. Tube twice the length of the calix. Upper lip helmet-ſhaped, with two awns. Lower lip reflected ; three concave ſegments, the middle one ſmaller. *Stamina* four filiform filaments, (two a little ſhorter than the other two) concealed by the upper lip. *Antheræ* cloven. *Germen* ovate ; compreſſed. *Stile* filiform ; longer than the ſtamina. *Stigma* obtuſe. *Capſule* ovate ; acuminated ; compreſſed ; with two cells and two valves. Seeds ovate ; ſeveral.

Stems erect. Leaves lanceolate ; deeply divided in a pinnated form ; the diviſions ſerrated. Bloſſoms in ſpikes ; yellow. Common in rich wood land. June.

MIMULUS. Linn. Gen. Plant. 701.

MAIDENWORT. Stems angular; branched. Leaves lanceolate; slightly serrated; opposite; half embracing the stalk. Blossoms solitary; on long flower-stalks rising from the *axillæ* of the leaves; blue. By fences in moist land. August.

TETRADYNAMIA.

SILICULOSÆ.

MYAGRUM. Linn. Gen. Plant. 713.

Myagrum siliculis ovatis pedunculatis polyspermis. Syst. Nat.

CAMLINE. Blossoms yellow. In fields amongst flax. June.

THLASPI. Linn. Gen. Plant. 719.

Thlaspi siliculis obcordatis, foliis radicalibus pinnatifidis. Syst. Nat.

MITHRIDATE. Shepherd's Purse. Shepherd's Pouch. Blossoms white. In corn fields, and about barns. April—June.

COCHLEARIA. Linn. Gen. Plant. 720.

Cochlearia foliis radicalibus subrotundis, caulinis oblongis, subsinuatis. Syst. Nat.

SCURVY-GRASS. Blossoms white. On high land. Not common in a wild state, but is frequently cultivated in gardens. May—June.

It is acrimonious; and the acrimony is said to reside in a very subtile essential oil. It is frequently eaten by country people as a sallad. Writers on sea-voyages give high encomiums on the Scurvygrass for its antiscorbutic virtues. Dr. *Withering* says, it is a powerful remedy in the pituitous asthma, and in what *Sydenham* calls the scorbutic rheumatism. A distilled water and a conserve is prepared from the leaves. The juice is prescribed along with that of oranges, by the name of antiscorbutic juices.

Cochlearia

Cochlearia foliis radicalibus lanceolatis integerrimis, caulinis subsinuatis. Syst. Nat.

SEA SCURVYGRASS. The leaves are fleshy. Blossoms white. On the sea shore and in marshes. May—June.

This is more acrimonious than the former species. It has a pretty full taste of sea salt, as well as the volatile alkali.

Cochlearia foliis lanceolatis amplexicaulibus dentatis. Syst. Nat.

HORSE-RADISH. Blossoms white. In rich soil in moist land. Not common in an uncultivated state. June—July.

It is so rarely found where it has not been cultivated, that it may possibly be doubted whether it be indigenous. The scraped roots are much used at tables as a condiment, and for many culinary purposes. It has been found a powerful stimulant in paralytic cases, and is useful as a diuretic in dropsies. A distilled water is prepared from it. A strong infusion is emetic.

SILIQUOSA.

CARDAMINE. Linn. Gen. Plant. 727.

Cardamine foliis pinnatis extipulatis, foliolis lanceolatis obtusis, floribus corollatis. Syst. Nat.

LADYSMOCK. Blossoms white. Near small brooks. Not common. May—June.

Cardamine foliis pinnatis : foliolis lanceolatis basi unidentatis. Syst. Nat.

IMPATIENT. *Impatient Ladysmock.* Blossoms yellowish white. By springs in mountainous land. Very rare. May.

SISYMBRIUM. Linn. Gen. Plant. 728.

Sisymbrium siliquis declinatis, foliis pinnatis : foliolis subcordatis. Syst. Nat.

WATERCRESS. Bloſſoms white. In ſprings and running brooks of water. May.

It is an early and wholeſome ſpring ſallad, and is uſed as a pot-herb. Dr. *Withering* ſays, it is an excellent antiſcorbutic and ſtomachic, with leſs acrimony than the ſcurvygraſs. It is an ingredient in the antiſcorbutic juices.

SINAPIS. Linn. Gen. Plant.

Sinapis ſiliquis glabris tetragonis. Syſt. Nat.

BLACK MUSTARD. Bloſſoms pale yellow. Common about barns. June.

The imported muſtard, ſo common at tables, and which is generally preferred to our own, is the pulverized ſeed of this ſpecies ;—the difference conſiſts only in the preparation of the powder. The ſeeds unbruiſed are frequently given in palſies and chronic rheumatiſms, and are found beneficial. They may be taken in the quantity of a table-ſpoon full, or more, and will gently relax the bowels. Rheumatic pains in the ſtomach are often relieved by taking them in brandy. The powdered ſeeds, with crumbs of bread and vinegar, are made into cataplaſms, and applied to the ſoles of the feet in fevers, when ſtimulants are neceſſary. They are alſo topically applied in fixed rheumatic and ſciatic pains. Dr. *Withering* ſays, wherever we want a ſtrong ſtimulus, that acts upon the nervous ſyſtem without exciting much heat, we know none preferable to the muſtard ſeed. An infuſion of the ſeed, given in large quantities, vomits ; but in ſmaller doſes, operates as an aperient and diuretic. Muſtard whey, with wine, is uſed as a drink in fevers. Its acrimony is ſaid to conſiſt in an eſſential oil.

RAPHANUS. Linn. Gen. Plant. 736.

Raphanus ſiliquis teretibus articulatis lævibus unilocularibus. Syſt. Nat.

CHARLOCK.

CHARLOCK. Bloſſoms white or yellow. Common amongſt rye, barley and flax. June—Auguſt.

It is often very injurious to grain; and when it has once got into the ground it is extremely difficult to extirpate. The ſeeds will remain in the ground many years, in a vegetive ſtate, after it is ſwarded over with graſs, and will grow when the ground is again plowed up. Dr. *Withering* ſays, in wet ſeaſons it grows in great quantity amongſt the barley in *Sweden*; and the common people, who eat barley bread, are afflicted with very violent convulſive complaints in thoſe provinces, and in thoſe ſeaſons wherein this plant abounds.

MONADELPHIA.

DECANDRIA.

GERANIUM. Linn. Gen. Plant. 746.

Geranium pedunculis ſubtrifloris, foliis cordatis crenato-inciſis ſubvilloſis, caulibus procumbentibus. Syſt. Nat.

SEA CRANESBILL. Bloſſoms pale red. In marſhes and on the ſea ſhore. June—July.

Geranium pedunculis bifloris, calycibus inflatis, piſtillo longiſſimo. Syſt. Nat.

COMMON CRANESBILL. Bloſſoms purple. By ſtone walls and borders of fields. May—July.

The root is aſtringent, and frequently uſed in gargles for cankerous ſores in the mouth and throat.

Geranium pedunculis bifloris, calycibus piloſis decemangulatis. Syſt. Nat.

MOUNTAIN CRANESBILL. Herb-Robert. Stockbill. Bloſſoms pale red. Amongſt rocks in high land. June—July.

It is conſiderably aſtringent, and ſmells ſomewhat like muſk. A decoction of the plant has been known to give relief in cal-

culous

culous cafes. It is given to cattle when they make bloody water.

POLYANDRIA.

ALTHÆA. Linn. Gen. Plant. 749.

Althæa foliis fimplicibus tomentofis. Syft. Nat.

MARSH-MALLOW. Bloffoms purplifh white. In marfhes on *Martha's Vineyard.* Auguft.

It is common in gardens, where it is cultivated for its medical virtues. The whole plant is mucilaginous, but the mucilage abounds moft in the roots. It is much ufed in cataplafms and fomentations as an emollient. An infufion, or decoction, is commonly ordered in all cafes which require mild mucilaginous fubftances.

MALVA. Linn. Gen. Plant. 751.

Malva caule repente, foliis cordato-orbiculatis obfolete quinquelobatis. Syft. Nat.

MALLOW. Bloffoms white, tinged with purple. Common about barns. June—September.

DIADELPHIA.

OCTANDRIA.

POLYGALA. Linn. Gen. Plant. 761.

Polygala floribus imberbibus oblongo-capitatis, caule erecto herbaceo fimpliciffimo, foliis lanceolatis acutis. Syft. Nat.

MILKWORT. Bloffoms red and yellow. Common in moift fields. Auguft—September.

This plant is generally called *Low Centaury*, and has, probably, been miftaken for a fpecies of the *Gentiana.*

Polygala.

LONG-SPIKED MILKWORT. Stems erect; branched. Leaves lanceolate. Bloffoms in long terminating fpikes; pale red. In moift land. Not common. Auguft.

DECANDRIA.

DECANDRIA.

GENISTA. Linn. Gen. Plant. 766.

Genista foliis lanceolatis glabris, ramis striatis teretibus erectis. Syst. Nat.

GREENWOOD. Dyer's Weed. Wood Waxen. Blossoms yellow. In pastures between *New-Mills* and *Salem.* June.

The blossoms afford a yellow colour. The powdered seeds operate as a mild purgative. A decoction of the plant is diuretic.

ÆSCHYNOMENE. Linn. Gen. Plant. 769.

Æschynomene caule hispido, leguminum articulis semicordatis, bracteis cordatis ciliatis, stipulis utrinque lanceolatis. Syst. Nat.

TOOTH-PODDED BEAN. Blossoms pale red. On the borders of fields. August.

LUPINUS. Linn. Gen. Plant. 774.

Lupinus calycibus alternis appendiculatis: labio superiore bipartito, inferiore integro. Syst. Nat.

LUPINE. Blossoms blue. In corn fields, in the state of *Connecticut.* June—August.

ROBINIA. Linn. Gen. Plant. 775.

Robinia pedunculis subdivisis, foliis pinnatis, floribus foliolo majoribus. Syst. Nat.

LOCUST-TREE. Blossoms white. In the woods in the southern states—only by cultivation here. June.

The wood, when green, is of a soft texture, but becomes very hard when it is thoroughly dry. It is as durable as the best white oak, and esteemed preferable for carriage axletrees, trannels for ships, and for many other mechanic purposes. It makes excellent fuel, and its shade is less injurious to grass than that of most other trees. It may be propagated with great ease and to very advantageous purposes.

PISUM.

PISUM. Linn. Gen. Plant. 779.

Pisum petiolis supra planiusculis, caule angulato, stipulis sagittatis, pedunculis multifloris. Syst. Nat.

SEA PEA. Blossoms pale red and purple. On sandy beaches near the sea. July—August. They are esculent.

Pisum petiolis decurrentibus membranaceis diphyllis, pedunculis unifloris. Syst. Nat.

PIED PEA. Blossoms red, purple and white. In rich moist land. June—July.

OROBUS. Linn. Gen. Plant. 780.

Orobus pinnatis ovatis stipulis semisagittatis integerrimis, caule simplici. Syst. Nat.

PEASELING. Blossoms purple. Near *New-Mills* in *Danvers.* June—July.

Oribus foliis pinnatis lanceolatis, stipulis semisagittatis integerrimis, caule simplici. Syst. Nat.

WOOD PEAS. Heath Peas. Blossoms red and yellow. In shrub-oak and pine land. July.

It is said, that the roots, when boiled, are savory and nutritious—Ground into powder, they may be made into bread.—That they are held in high esteem by the Highlanders in *Scotland*, who chew them as people do tobacco, and find that they prevent the uneasy sensation of hunger. They imagine, that they promote expectoration, and are very efficacious in curing disorders of the lungs. They know how to prepare an intoxicating liquor from them.

Orobus caulibus decumbentibus hirsutis ramosis. Syst. Nat.

WOOD PEASELING. Blossoms redish white. Borders of wood land. July.

LATHYRUS.

LATHYRUS. Linn. Gen. Plant. 781.

Lathyrus pedunculis multifloris, cirrhis diphillis : foliolis ovalibus, internodiis nudis. Syst. Nat.

VETCHLING. Bloſſoms purple. Sandy beaches. July.

Lathyrus pedunculis multifloris, cirrhis polyphyllis, ſtipulis ovatis : baſi acutis. Syſt. Nat.

CHICKLING PEAS. Bloſſoms purple and white. In *Salem*, near the ſea. July.

VICIA. Linn. Gen. Plant. 782.

Vicia leguminibus pedicellatis ſubquaternis erectis, foliolis ovatis integerrimis : exterioribus decreſcentibus. Syſt. Nat.

VETCH. Bloſſoms purple. Borders of fields. July.

INDIGOFERA. Linn. Gen. Plant. 794.

Indigofera leguminibus horizontalibus teretibus, foliis pinnatis ternatiſque ? Syſt. Nat.

INDIGOWEED. Bloſſoms yellow. Common in paſtures and woods. July—Auguſt.

A durable pale blue may be obtained from the leaves and ſmall branches. Fomentations of the plant, it is ſaid, will abate the ſwelling, and counteract the poiſon in the bite of rattle-ſnakes.

TRIFOLIUM. Linn. Gen. Plant. 802.

The indigenous ſpecies of this genus are too numerous to admit of a particular deſcription. Several of them are generally known, viz. The *Melilot Clover*. The *Creeping Clover*. The *White Honeyſuckle*. The *Red Honeyſuckle*. The *Yellow Clover*. The *Woolly-headed Clover*, or *Chuckle-head*. The *Tall Trefoil*.

MEDICAGO. Linn. Gen. Plant. 805.

GROUND NUT. The germen is rolled inwards, but the pod becomes nearly ſtrait, containing ſeveral kidney-ſhaped ſeeds.

Stems twining. Bloſſoms in cluſters, placed in the *axillæ* of the leaves; red or red and white. Common in loamy wood land. July.

The roots are roundiſh and eſculent, and were eaten by the Indians.

POLYADELPHIA.

POLYANDRIA.

HYPERICUM. Linn. Gen. Plant. 808.

Hypericum floribus trigynis: petatis calyce ſublongioribus, foliis ovali-oblongis obtuſis ſemiamplexicaulibus, caule tereti. Syſt. Nat.

TUTSAN. All Saint's Wort. Bloſſoms pale red. Moiſt land. Auguſt.

Hypericum floribus trigynis, caule quadrato herbaceo. Syſt. Nat.

St. PETER's WORT. Bloſſoms yellow. Moiſt meadows. July.

Hypericum floribus trigynis, caule ancipiti, foliis obtuſis pellucido-punctatis. Syſt. Nat.

St. JOHN's WORT. Bloſſoms yellow. In fields. July—Aug.

The ſmall dots upon the leaves, which appear like ſo many perforations, are ſaid to contain an eſſential oil. The leaves are given to deſtroy worms. The flowers tinge ſpirits and oil of a fine purple colour.

SYNGENESIA.

POLYGAMIA ÆQUALIS.

SONCHUS. Linn. Gen. Plant. 813.

Sonchus pedunculis hiſpidis, floribus racemoſis, foliis lyrato-haſtatis. Syſt. Nat.

SOWTHISTLE. Bloſſoms purple. On ditch banks. Auguſt—September.

LACTUCA,

LACTUCA. Linn. Gen. Plant. 814.

Lactuca foliis laciniato-ensiformibus dentatis inermibus. Syst. Nat.

WILD LETTUCE. Milkweed. Blossoms yellow. About barns and fields. August—September.

The milky juice is said to possess the properties of opium. It may be collected in shells, dried by a gentle heat, and made into pills.

PRENANTHES. Linn. Gen. Plant. 816.

Prenanthes flosculis plurimis, floribus nutantibus subumbellatis, foliis hastato-angulatis. Syst. Nat.

IVYLEAF. Ivy-leafed Wild Lettuce. Snake-weed. Blossoms white. By stone walls in rich moist land. August.

LEONTODON. Linn. Gen. Plant. 817.

Leontodon calyce inferne reflexo. Syst. Nat.

DANDELION. Blossoms yellow. Grass land. May—Sept.

The leaves, early in the spring, are much esteemed as a pot-herb and in sallads. It is sometimes transplanted into gardens, and blanched like endive. The *French* eat the roots and leaves with bread and butter. It is in a considerable degree diuretic. *Boerhaave* had a great opinion of the utility of this and other lactescent plants in obstructions of the viscera. The expressed juice is said to have been given, to the quantity of four ounces, three or four times a day.

HIERACIUM. Linn. Gen. Plant. 629.

Hieracium caule multifloro, foliis lyratis glabris, calyce pedunculisque hispidis. Syst. Nat.

HAWKWEED. Blossoms yellow. About barns and rubbish. August.

Hieracium caule erecto multifloro, foliis lanceolatis dentatis, pedunculis tomentosis. Syst. Nat.

RATTLE-SNAKE PLANTAIN. *Poor Robin's Plantain.* Blossoms pale yellow. The radical leaves are of a reddish colour, and spread on the ground like plantain. In woods. June—Aug.

It is said to have been considered by the Indians as an infallible cure for the bite of rattle-snakes. They chewed the leaves in the mouth, and, after swallowing part of the juice, applied them to the wound. This is, probably, the plant which *Carver* says the Indians were convinced was such a powerful antidote, that for a trifling bribe of spiritous liquors, they would at any time permit a rattle-snake to drive his fangs into their flesh.

CREPIS. Linn. Gen. Plant. 819.

Crepis involucris calyce longioribus : squamis setaceis sparsis. Syst. Nat.

BLUE SUCCORY. Blossoms blue. Fields in *Cambridge*. July. It is said to be a good stamachic.

Crepis involucris ovatis concavis obtusis patentibus. Syst. Nat.

YELLOW SUCCORY. Blossoms yellow. Wood land. August.

ARCTIUM. Linn. Gen. Plant. 830.

Arctium foliis cordatis inermibus petiolatis. Syst. Nat.

BURDOCK. Blossoms purple. About barns. July—Aug.

The young stems boiled, divested of the bark, are esteemed little inferior to asparagus. They are also eaten raw with oil and vinegar. Dr. *Withering* says, a decoction of the roots is esteemed, by some very sensible physicians, as equal, if not superior, to that of sarsaparilla.

SERRATULA.

SERRATULA. Linn. Gen. Plant. 831.

Serratula foliis lanceolatis, ſquamis calycinis apice membranaceis obtuſis patulis coloratis, floribus terminalibus. Syſt. Nat.

DEVIL's BIT. The root appears as if bitten off. Bloſſoms purple. Old fields. Auguſt—September.

In *England*, a plant of the fourth claſs is called *Devil's Bit*, the *Scabioſa ſucciſa*. Linn. *Morſus diaboli vulgaris, flore purpureo.* Park. An infuſion of the roots of this plant, in a cloſe veſſel, has been found very ſerviceable in ſcrophulus complaints.

CARDUUS. Linn. Gen. Plant. 832.

Carduus foliis ſinnatis decurrentibus : margine ſpinoſis, calycibus pedunculatis ſolitariis erectis villoſis. Syſt. Nat.

WELTED THISTLE. Bloſſoms pale red. Road ſides. July.

Carduus foliis ſeſſilibus bifariam pinnatifidis : laciniis alternis erectis, erectis, calycibus globoſis villoſis. Syſt. Nat.

STAR THISTLE. Friar's Crown. Bloſſoms purple. In paſtures. July—Auguſt.

Carduus foliis pinnatifidis ſpinoſis ſeſſilibus, caule inermi, floribus ſolitariis. Syſt. Nat.

LADIES THISTLE. Bloſſoms purple. Road ſides. July.

Carduus foliis lanceolatis dentatis amplexicaulibus : ſpinulis inæqualibus ciliatis, caule inermi. Syſt. Nat.

YELLOW THISTLE. Bloſſoms yellow. In *Chelſea*. June.

The flowers of thiſtles have the property of rennet in curdling milk.

CARLINA. Linn. Gen. Plant. 836.

Carlina caule multifloro corymboſo, floribus terminalibus. Syſt. Nat.

FIRE-WEED. Bloſſoms white. It abounds in new plantations where the ground has been burnt over. Aug.

BIDENS.

BIDENS. Linn. Gen. Plant. 840.

Bidens foliis pinnatis ſerratis glabris, ſeminibus erectis, calycibus frondoſis, caule lævi. Syſt. Nat.

HARVEST-LICE. Cuckold. Bloſſoms yellow. In corn fields. September.

EUPATORIUM. Linn. Gen. Plant. 842.

Eupatoriun foliis quaternis ſcabris lanceolato-ovatis inæqualiter ſerratis petiolatis rugoſis. Syſt. Nat.

LIVER-HEMP. Honeſty. Hemp Agrimony. Bloſſoms pale red. In moiſt land, by brooks and rivers. July—Auguſt.

Dr. *Withering* ſays, an infuſion of an handful of it, vomits and purges ſmartly. An ounce of the root, in decoction, is a full doſe. In ſmaller doſes the *Dutch* peaſants take it as an alterative and an antiſcorbutic.

Eupatorium foliis connatis tomentoſis. Syſt. Nat.

THOROUGH-WAX. Bloſſoms white. In moiſt land. July—Auguſt.

The *Bupleurum rotundifolium.* Linn. The *Perfoliata vulgaris.* Park. of the fifth claſs, is called *Thorough-wax* in *England.* An infuſion of the leaves is a powerful emetic.

AGERATUM. Linn. Gen. Plant. 843.

Ageratum foliis ovatis crenatis obtuſis, caule glabro. Syſt. Nat.

MEADOW SUNFLOWER. Bloſſoms yellow. In wet meadows. September.

STÆHELINA. Linn. Gen. Plant. 844.

Stæhelina foliis ſubtrigonis, ſquamis calycinis crenatis. Syſt. Nat.

PRICKLY DEVIL's-BIT. Bloſſoms purple. On *Winter-Hill* in *Charleſtown.* July—Auguſt.

POLYGAMIA

POLYGAMIA SUPERFLUA.

TANACETUM. Linn. Gen. Plant. 848.

Tanacetum foliis bipinnatis serratis. Syst. Nat.

TANSEY. Bloſſoms yellow. Paſtures. Auguſt.

The leaves are frequently uſed to give a colour and flavour to pudding. Freſh meat may be preſerved from the attacks of the fleſh-fly, by rubbing it with this plant. It is conſidered as a warm deobſtruent bitter. The *Finlanders* are ſaid to obtain a green dye from it.

ARTEMISIA. Linn. Gen. Plant. 849.

Artemiſia foliis compoſitis multifidis, floribus ſubgloboſis pendulis: receptaculo villoſo. Syſt. Nat.

WORMWOOD. Bloſſoms browniſh white. Road ſides, and amongſt rubbiſh. July—Auguſt.

The leaves and flowers are well known to be bitter, and to reſiſt putrefaction. They are made a principle ingredient in antiſceptic fomentations. The roots are warm and aromatic. The plant affords a conſiderable quantity of eſſential oil, by diſtillation, which is uſed both internally and externally to deſtroy worms. Fomentations, or cataplaſms of the leaves are ſometimes applied to the bellies of children in obſtinate worm caſes. An infuſion of the leaves is ſaid to be a good ſtomachic, and with the addition of fixed alkaline ſalt, a powerful diuretic in dropſical caſes. *Linnæus* has mentioned two caſes, wherein an eſſence, prepared from this plant, and taken for a conſiderable time, prevented the formation of ſtones in the kidneys and bladder—the patients forbearing the uſe of wine and acids. If women, that ſuckle, take an infuſion of this plant, it makes their milk bitter. The leaves put into ſour beer, ſoon deſtroy the aceſcency.

Artemiſia

Artemiſia foliis pinnatifidis planis inciſis ſubtus tomentoſis, racemis ſimplicibus, floribus ovatis : radio quinquefloro. Syſt. Nat.

MUGWORT. Bloſſoms purpliſh. Borders of fields. Aug. Dr. *Withering* ſays, in ſome countries it is uſed as a culinary aromatic. A decoction of it is taken by the common people to cure the ague.

GNAPHALIUM. Linn. Gen. Plant. 850.

Gnaphalium foliis ſemiamplexicaulibus enſiformibus repandis obtuſis utrinque pubeſcentibus, floribus conglomeratis. Syſt. Nat.

CATSFOOT. Woolly Mouſe-Ear. Bloſſoms yellowiſh white. Road ſides. Auguſt.

Gnaphalium foliis decurrentibus obtuſis mucronatis utrinque tomentoſis planis. Syſt. Nat.

LIFE-EVERLASTING. Bloſſoms white. In paſtures and fields. September.

NONE-SO-PRETTY. Stems herbaceous ; branched. Leaves ovate ; ſlightly ſerrated ; ſeſſile ; alternate. Bloſſoms in broad topped ſpikes ; rediſh purple. Female florets in the circumference, and without petals.

ERIGERON. Linn. Gen. Plant. 855.

Erigeron ramis lateralibus multifloris, calycibus ſquarroſis. Syſt. Nat.

FLEABANE. Florets in the circumference white ; thoſe in the center purple. By fences. Auguſt.

Erigeron caule floribuſque paniculatis. Syſt. Nat.

MEADOW FLEBANE. Florets in the circumference white ; thoſe in the center yellow. Moiſt land. Auguſt—September.

Erigeron pedunculis alternis unifloro. Syſt. Nat.

ROSEBETTY. Bloſſoms in the circumference purple ; thoſe in the center yellow. By fences. Auguſt—Sept.

TUSSILAGO.

TUSSILAGO. Linn. Gen. Plant. 856.

Tussilago scapo imbricato unifloro, foliis subcordatis angulatis denticulatis. Syst. Nat.

COLTSFOOT. Blossoms yellow. About barns. April.

Dr. *Withering* says, the leaves are the basis of the *British* herb tobacco.—They are somewhat austre, bitterish, and mucilaginous to the taste. They have been much used in coughs and consumptive complaints. Dr. *Cullen* has found them to do considerable service in scrophulous cases.—He gives a decoction of the dried leaves, and finds it succeed where sea-water has failed.

SENECIO. Linn. Gen. Plant. 857.

Senecio corollis radiantibus, foliis ensiformibus acute serratis subtus subvillosis, caule stricto? Syst. Nat.

GROUNDSEL. Stanchbood. Blossoms in branched particles; white. Borders of corn fields. August—October.

This plant has been found very efficacious in stopping hermorrhages in certain persons, subject to a very singular kind of constitutional bleeding, when other means have failed. If the bleeding be occasioned by the rupture of internal blood-vessels, they drink a strong decoction of the plant: if it be external, they both drink the decoction, and apply to the wound the fresh leaves bruised, or the dried plant in form of a poultice.

ASTER. Linn. Gen. Plant. 858.

Aster foliis linearibus integerrimis, caule paniculato. Syst. Nat.

BUSHY ASTER. Florets in the circumference white, tinged with red; in the center yellow. By fences. September.

Aster foliis linearibus acutis integerrimis, caule corymboso ramosissimo. Syst. Nat.

 DWARF ASTER.

DWARF ASTER. Florets in the circumference purple; in the center yellow. In hedges. August.

Aster foliis lanceolatis integerrimis semiamplexicaulibus, floribus confertis terminalibus, pedunculis nudis, caule hispido. Syst. Nat.

NEW-ENGLAND ASTER. Florets in the circumference purple; in the center yellow. Borders of fields. Aug.—Sept.

SOLIDAGO. Linn. Gen. Plant. 859.

Solidago paniculato-corymbosa, racemis recurvatis, floribus adscendentibus, foliis trinerviis subserratis scabris. Syst. Nat.

ROUGH-LEAVED GOLDENROD. Blossoms yellow. Borders of fields. August.

Solidago paniculato-corymbosa, racemis recurvis, floribus adscendentibus, foliis enerviis, subintegerrimis. Syst. Nat.

SMOOTH-LEAVED GOLDENROD. Blossoms yellow. Borders of fields. August.

Solidago caule obliquo, pedunculis erectis foliolatis ramosis, foliis lanceolatis integerrimis. Syst. Nat.

MARSH GOLDENROD. Blossoms yellow. Borders of marshes. August.

INULA. Linn. Gen. Plant. 860.

Inula foliis ovatis rugosis subtus tomentosis, calycum squamis ovatis. Syst. Nat.

ELECAMPANE. Blossoms yellow. Road sides. August.

Dr. *Withering* says, the root is esteemed a good pectoral. Dr. *Hill* says, he knows, from his own experience, that an infusion of the fresh root, sweetened with honey, is an excellent medicine in the hooping cough.

CHRYSANTHEMUM.

CHRYSANTHEMUM. Linn. Gen. Plant. 866.

Chryſanthemum foliis amplexicaulibus oblongis : ſuperne ſerratis ; inferne dentatis. Syſt. Nat.

WHITE WEED. Goldens. Daiſie. Florets in the circumference white ; in the center yellow. In fields and paſtures. May—June. The young leaves may be eaten as ſallad. It is very injurious to graſs land.

ANTHEMIS. Linn. Gen. Plant. 876.

Anthemis receptaculis conicis : paleis ſetaceis, ſeminibus nudis. Syſt. Nat.

MAY-WEED. Florets in the circumference white ; in the center yellow. Road ſides. June—Auguſt.

It is ſaid to be grateful to toads, and very ungrateful to bees.

ACHILLEA. Linn. Gen. Plant. 871.

Achillea foliis bipinnatis nudis : laciniis linearibus dentatis. Syſt. Nat.

YARROW. Bloſſoms white. In dry paſtures. June—Aug.

Dr. *Withering* ſays, the flowers yield an eſſential oil :—that the leaves are celebrated by the *materia medica* writers for a variety of purpoſes, but they are little attended to at preſent.

POLYGAMIA FRUSTRANEA.

HELIANTHUS. Linn. Gen. Plant. 877.

Helianthus foliis oppoſitis ſeſſilibus ovato-oblongis trinerviis panicula dichotoma. Syſt. Nat.

ROUGH-LEAVED SUNFLOWER. Bloſſoms yellow. Borders of fields. Auguſt—September.

It is, in a conſiderable degree, aſtringent. A decoction of the plant is much eſteemed by the common people in diarrhæas.

RUDBECKIA ? Linn. Gen. Plant. 878.

AMERICAN GLOBE AMARANTHUS. The leaves lanceolate ; alternate ; ſeſſile ; downy. Stems woolly. Bloſſoms globular.

Barren florets numerous; entire; white.—Fertile florets ſmall; yellow. They ſtand in a broad-topped ſpike. The bloſſoms are durable after they are taken off. It makes a pretty appearance in flower borders. In high, rich paſtures. Aug.—Oct.

COREOPSIS. Linn. Gen. Plant. 879.

Coreopſis foliis pinnatis ſerratis, radio florum diverſicolore. Syſt. Nat.

MEADOW CUCKOLD. Bloſſoms yellow, red, and white. In wet meadows. Auguſt.

MONOGAMIA.

LOBELIA. Linn. Gen. Plant. 897.

Lobelia caule erecto, foliis lanceolato-linearibus obtuſiuſculis alternis integerrimis, racemo terminali. Syſt. Nat.

SPINET. Bloſſoms blue. In moiſt graſs land. June—July.

Lobelia caule erecto, foliis lanceolatis ſerratis ſpica terminali. Syſt. Nat.

AMERICAN PRIDE. Bloſſoms ſcarlet. Borders of brooks and rivers. Auguſt.

Lobelia.

EMETICWEED. The leaves oblong; ſlightly ſerrated; ſeſſile; alternate; on the upper ſurface numerous tubercles. Stems branched. Bloſſoms ſolitary; in a kind of ſpike; pale blue. Common in dry fields. Auguſt.

The leaves chewed in the mouth are, at firſt, inſipid, but ſoon become pungent, occaſioning a copious diſcharge of ſaliva. If they are held in the mouth for ſome time, they produce giddineſs and pain in the head, with a trembling agitation of the whole body: at length they bring an extreme nauſea and vomiting. The taſte reſembles that of tarter emetic. A plant poſſeſſed

possessed of such active properties, notwithstanding the violent effects from chewing the leaves, may possibly become a valuable medicine.

VIOLA. Linn. Gen. Plant. 898.

Viola acaulis, foliis pinnatifidis. Syst. Nat.

MOUNTAIN VIOLET. Blossoms variegated. On the hills in *Lynn.* October.

Viola acaulis, foliis reniformibus. Syst. Nat.

MARSH VIOLET. Blossoms pale blue. In moist meadows. April.

Viola acaulis, foliis cordatis, stolonibus reptantibus. Syst. Nat.

SWEET VIOLET. Blossoms deepish purple. In moist warm land. April.

The flowers and the seeds are said to be mild laxatives. The leaves give the blue colour to the sirup of violets, which is changed by an acid to red, and by an alkali to green. It is said, that slips of white paper stained with the petals, and kept from the air and the light, will be changed in the same manner.

Viola caule erecto, foliis cordatis acuminatis. Syst. Nat.

YELLOW VIOLET. Blossoms yellow. In shady places. May.

It is said the Indians applied the bruised leaves to boils and painful swellings, for the purpose of easing the pain and producing suppuration.

IMPATIENS. Linn. Gen. Plant. 899.

Impatiens pedunculis multifloris solitariis foliis ovatis, geniculis caulinis tumentibus. Syst. Nat.

WEATHERCOCK. Balsamine. Touch-me-not. Quick-in-the-Hand. Blossoms yellow. Banks of rivulets. July—Aug.

It

It is generally known here by the name of *Celandine*, and is much celebrated among the common people for curing the jaundice.

GYNANDRIA.

DIANDRIA.

ORCHIS. Linn. Gen. Plant. 900.

Orchis nectarii cornu setaceo longitudine germinis: labio tripartito ciliari. Syst. Nat.

LADY's PLUME. Female-handed Orchis. Blossoms in large spikes; white, or purplish, or flesh-colour'd. In wet meadows. August.

OPHRYS. Linn. Gen. Plant. 902.

Ophrys bulbis aggregatis oblongis caule subfolioso, floribus secundis, nectarii labio indiviso. Syst. Nat.

TRIPLE LADY's TRACES. Blossoms in a spiral spike; yellowish white. In moist land. August.

ARETHUSA? Linn. Gen. Plant. 905.

Arethusa radice globosa, scapo vaginato, spatha diphylla. Syst. Nat.

RED-WINGED ORCHIS. Blossoms red or purple. In mossy meadows. August.

CYRRIPEDIUM. Linn. Gen. Plant. 906.

Cyrripedium radicibus fibrosis, foliis ovato-lanceolatis caulinis. Syst. Nat.

LADY's SLIPPER. The petals red. *Nectarium* flesh-colour'd, with dark red veins. In moist shady places. May—June.

Catesby says, the flowers of this plant, which are very singular, were in great esteem with the Indians for decking their hair.

hair. They called it the *Moccasin Flower.* It is easily propagated in gardens by transplanting the roots, which are perennial.

TRIANDRIA.

SISYRINCHIUM. Linn. Gen. Plant. 908.

Sisyrinchium caule foliisque ancipitibus. Syst. Nat.

BLUE-EYED GRASS. Blossoms blue. In grass land. May—June. It makes very pretty edging for borders in gardens.

POLYANDRIA.

ARUM. Linn. Gen. Plant. 915.

Arum acaule, foliis hastato-cordatis acutis : angulis obtusis. Syst. Nat.

CUCKOWPINT. *Dragon-root.* *Wake-Robin.* *Lords & Ladies.* *Spatha* striped with red or black. Berries red.

The fresh root is extremely acrid. The dried root, grated into water, is frequently given as a carminative. It is said the Indians boiled both the shreded roots and berries with their venison. Dr. *Withering* says, the root has been employed in medicine as a stimulant, but when reduced to powder it looses much of its acrimony ; and there is reason to suppose, that the compound powder which takes its name from this plant, owes its virtue chiefly to the other ingredients ;—that there is no doubt but the acrid quality of the plant may be turned to very useful purposes ; but we must first learn how to ascertain its dose. He says, the root, dried and powdered, is used by the *French* to wash their skin with.—It is sold at a high price, under the name of Cypress Powder.—It is undoubtedly a good and an innocent cosmetic.—When the acrimony of the roots is extracted, by boiling or baking, they afford a very mild and wholesome nourishment.—Many nations prepare the only bread they have from plants as acrimonious as this ; first dissipating the

the noxious qualities by the force of heat.—Starch may be made from the roots.

CALLA. Linn. Gen. Plant. 917.

Calla foliis cordatis, ſpatha plana, ſpadice undique hermaphrodito. Syſt. Nat.

HEART-LEAF FLAG. *Spatha* on the inner ſide white. Stamina yellow. Berries red. In watery places.

MONOECIA.

MONANDRIA.

ZANNICHELLIA. Linn. Gen. Plant. 920.

ODDITY. Stems hairy; erect. Leaves ovate; ſlightly ſerrated; alternate. Bloſſoms in pairs in the *axillæ* of the leaves. The calix tinged with red. In paſtures. September.

ELATERIUM. Linn. Gen. Plant. 1036. 6 Edit.

WILD CUCUMBER. The ſtems, leaves and bloſſoms like thoſe of the cucumber. *Hampton* falls, in the ſtate of *New-Hampſhire.* Auguſt—September.

TETANDRIA.

BETULA. Linn. Gen. Plant. 933.

The limits of this paper will admit of giving only the *Engliſh* names of this and the following genera of trees.——The *White Birch.* The *Black Birch.* The *Alder*, or *Owler.*

URTICA. Linn. Gen. Plant. 935.

Urtica foliis oppoſitis ovalibus. Syſt. Nat.

NETTLE. *Stinging Nettle.* The leaves are deeply ſerrated. The young ſhoots, early in the ſpring, are a good pot-herb. A leaf put upon the tongue, and preſſed againſt the roof of the mouth, is ſaid to be efficacious in ſtopping a bleeding at the noſe.

nose. The parts affected in paralytic cases have been recovered by stinging them with this plant. Dr. *Withering* says, the stings are very curious microscopic objects.—They consist of an exceeding fine pointed, tapering, hollow substance, with a perforation at the point, and a bag at the base. When the sting is pressed upon, it readily punctures the skin; and the same pressure forces up an acrimonious fluid from the bag, which instantly squirts into the wound, and produces an effect which almost every one has experienced. The stalks are dressed like flax, for making cloth or paper. The leaves cut fine, and mixed with dough, are very good for young turkeys.

PENTANDRIA.

AMBROSIA. Linn. Gen. Plant. 938.

Ambrosia foliis bipinnatifidis: racemis paniculatis terminalibus glabris. Syst. Nat.

CONOT-WEED. Roman Wormwood. In great plenty on the borders of cultivated fields. September.

It is generally called *Roman Wormwood*, and seems to have been mistaken for the *Artemisia maritima*. Linn. It has somewhat the smell of camphire. It is used in antisceptic fomentations. When it abounds amongst rye or barley, the seeds are thrashed out with the grain, and will give bread, made of it, a bitter and disagreeable taste.

AMARANTHUS. Linn. Gen. Plant. 941.

Amaranthus racemis pentandris compositis erectis foliis oblongo-ovatis. Syst. Nat.

HOG-WEED. White Amaranthus. Amongst rubbish. August.

Amaranthus racemis pentandris compositis patulo-nutantibus, foliis lanceolato-ovatis. Syst. Nat.

BLOODY AMARANTHUS. *Love-lies-a-bleeding*. *Princes Feather*. Amongst rubbish. August.

A decoction of this plant, drank freely, has been found efficacious in uterine hæmorrhages, when other powerful styptics have failed.

POLYANDRIA.

QUERCUS. Linn. Gen. Plant. 949.

The *White Oak*. The *Red Oak*. The *Yellow Oak*. The *Grey Oak*. The *Black Oak*. The *Swamp Oak*. The *Chesnut Oak*. The *Shrub Oak*.

JUGLANS. Linn. Gen. Plant. 950.

The *White Walnut*. The *Red-hearted Walnut*. The *Oil Nut*, or *Butter Nut*.

FAGUS. Linn. Gen. 951.

The *Larger Chesnut*. The *Smaller Chesnut*, with egg-shaped nuts. The *Beech*.

CARPINUS. Linn. Gen. Plant. 952.

The *Horn Beam*.

CORYLUS. Linn. Gen. Plant. 953.

The *Round-shelled Hazle*. The *Long-shelled Hazle*.

LIQUIDAMBAR. Linn. Gen. Plant. 955.

Liquidambar foliis oblongis sinuatis. Syst. Nat.

SWEET FERN. A small shrub. Common in dry pastures. July—August.

MONADELPHIA.

PINUS. Linn. Gen. Plant. 956.

The *White Pine*. The *Yellow Pine*. The *Pitch Pine*. The Norway *Pine*. The *White Cedar*. The *Red Cedar*. The *Fir*. The *Hemlock*. The *Spruce*. The *Taccamahac*.

DIOECIA.

DIOECIA.

DIANDRIA.

SALIX. Linn. Gen. Plant. 976.

The *White Willow.* The *Red Willow.* The *Rose Willow.* The *Dogwood.* The *Osier.*

An account is given, in the Transactions of the Royal Society, (vol. liii. p. 195) by the Rev. Mr. *Stone*, of the great efficacy of white willow bark in curing intermitting fevers. He gathered the bark in summer, when it was full of sap;—dried it by a gentle heat, and gave a dram of it powdered, every four hours betwixt the fits. In a few obstinate cases he mixed it with one fifth part of *Peruvian* bark. Some judicious physicians, here, have made trial of the bark of the white willow, and recommend it as a valuable substitute for the *Peruvian* bark. They have used principally the bark of the roots.

HEXANDRIA.

SMILAX. Linn. Gen. Plant. 992.

Smilax caule inermi tereti, foliis inermibus : caulinis cordatis, rameis ovato-oblongis ? Syst. Nat.

BIND-WEED. Bramble. Blossoms greenish white. Berries black. In moist hedges. June.

OCTANDRIA.

POPULUS. Linn. Gen. Plant. 996.

The *White Poplar.* The *Trembling Poplar,* or *Aspen Tree.* The *Black Poplar*, commonly called, in the northern states, the *Balm of Gilead.*

POLYANDRIA.

CLIFFORTIA. Linn. Gen. Plant. 1004.

Cliffortia foliis ternatis : intermedio tridentato. Syst. Nat.

THREE-LEAVED CLIFFORTIA. Snake-weed. In moist land. May—June.

POLYGAMIA.

MONOECIA.

VERATRUM. Linn. Gen. Plant. 1013.

Veratrum racemo supradecomposito, corollis erectis. Syst. Nat.

WHITE HELEBORE. *Poke-root. Indian Poke.* Common in wet meadows and swamps. June.

The root is a most drastic cathartic and sternutatory. The fresh roots, beaten up with hog's lard, cures the itch. It is said, the roots are poisonous to swine. Crows may be destroyed by boiling Indian corn in a strong decoction of the fresh roots, and strewing it on the ground where they resort.

ACER. Linn. Gen. Plant. 1023.

The *Great Maple*, or *Sycamore Tree*. The *Rock Maple*. The *Sugar Maple*.

DIOECIA.

FRAXINUS. Linn. Gen. Plant. 1026.

The *White Ash*. The *Red Ash*. The *Black Ash*. The *Prickley Ash*.

PANAX. Linn. Gen. Plant. 1031.

Panax foliis ternis quinatis. Syst. Nat.

GINSENG. *Ninsin.* It is said to grow plentifully in some parts of this, and in some of the neighbouring states. May—June.

This plant is the famous *panacea* of the *Chinese*, to which they have recourse in all diseases, as the last remedy. The *European* physicians esteem it a good medicine in convulsions, vertigoes, and all nervous complaints, and recommend it as one of the best restoratives known. Its dose is from ten grains to twenty, in powder; and from one dram to two to the pint, in infusions. An infusion of the leaves is drank among the *Chinese* and *Tartars*, by people of distinction, instead of tea; but it

it is too dear for the common people to ufe. The dried roots and leaves are faid to be fold amongft them for three times their weight in filver. The young roots are preferred to the old. They collect the roots only in the fpring and fall. They are wafhed in a decoction of millet feed, and then fufpended over the fumes of the fame liquor, in a clofe veffel, while it is boiling. After this, they dry it for ufe ; and when dried, it becomes almoft tranfparent. The young fibres which are taken off, they boil in water, and make an extract of them, which they ufe in the fame intention with the root. From the quantity that grows in this country, and the demand for it in the *Eaft-Indies*, and other parts of the world, we have reafon to hope it will become a valuable export.

The indigenous plants of the twenty-fourth clafs, whofe flowers are inconfpicuous, are too numerous to be defcribed in this paper.

XXV. *A Letter on the Retreat of Houſe-Swallows in Winter, from the Honourable* SAMUEL DEXTER, *Eſq; to the Honourable* JAMES BOWDOIN, *Eſq; Preſ. A. A.*

Dedham, June 3, 1783.

DEAR SIR,

AMONG more important branches of natural hiſtory, with which you are converſant, ornithology cannot have eſcaped your notice.

I know it has been a problem among naturaliſts, whether certain ſpecies of birds emigrate in autumn to diſtant countries, and return in the ſpring, or remain with us during the winter, in a torpid ſtate; and that the former opinion has generally prevailed. When, therefore, I acquaint you that I have adopted the latter, with reſpect to the *houſe-ſwallow*, you will juſtly expect that I give you ſubſtantial reaſons for differing from ſo many who have maintained the contrary.

The late Judge *Foſter*, of *Brookfield*, a year or two before his death, aſſured me, that he ſaw a certain pond drained, about the ſeaſon of the year when the ſwallows firſt appear. The buſineſs being effected, and the weather fair and warm, he, with ſeveral others, obſerved a rippling motion in many parts of the emptied hollow; which, on a near inſpection, they found to be occaſioned by a multitude of ſwallows, endeavouring to diſengage themſelves from the mud, which was ſcarcely covered by the ſhallow remains of water.

I ſhall now mention ſome other facts, which render it probable, that this ſort of ſwallows ſink into ponds and rivers, in the fall of the year, and lie there, benumbed and motionleſs, until the return of ſpring.

You

You know, Sir, that my houſe is near a large river. This river is, in many parts, ſhallow, and has a muddy bottom. A former neighbour of mine, a plain, honeſt and ſenſible man, now deceaſed, who lived ſtill nearer to the river, uſed frequently to ſay to me, as the warm weather came on in the ſpring, "it is almoſt time for the ſwallows to come out of the mud, where they have lain all winter." On my calling his philoſophy, once and again, in queſtion, and ſaying, as I formerly believed, that doubtleſs they were birds of paſſage, he has repeatedly aſſured me, he had, in the autumn of many years, ſeen great numbers of them, on one day only in each year, and nearly about, but not always on the ſame day of the month, ſitting on the willow buſhes, (which, by the way, they are not wont to rooſt upon at other times) on the borders of the river, a little after ſunſet :—That they ſeemed as if their torpitude had already begun, as they would not ſtir from the twigs, which, by the weight of the ſwallows, were bent down almoſt to the water ;—and that although he had never ſeen them ſink into it, yet he had waited till it was ſo dark that he could not diſcern them at all ; and doubted not of their immerſion any more than if he had been a witneſs of it ; for he had never obſerved any flying about afterwards, till the return of ſpring. He added, that if, as he wiſhed, I would carefully look out for their reſurrection, he believed it would not be in vain. He had, he ſaid, often taken notice that only a few appeared at firſt, and the main body in about a week after.

Although I paid little regard to it for ſome years, yet I followed his advice at length, and watched for their appearance ſeveral ſeaſons, as carefully as I could. I have not indeed beheld them riſing out of the water ; yet I and my family have, in more

more years than one, ſeen, at the proper time in the ſpring, very large flocks of them, in my own, and in my neighbour's land, ſo near the margin of the river, that, from that circumſtance, the appearance of their feathers, and their being unable to uſe their wings as at other times, we concluded they were newly emerged from the water. When they attempted to fly, they could not reach above eight or ten yards before they ſettled to the ground, and then might be drove about like chickens. They appeared unwilling to be diſturbed; and, if not frightened by ſome noiſe or motion, would cluſter together, ſeeming to want to reſt themſelves, as if feeble, or fatigued.—They were not entirely recovered from their ſtupor,—there was a viſcous ſubſtance on and about their wings,—or they were too weak to fly away. We had ſeen none in thoſe years before; but in each of them, after a day or two, they were flying about as uſual in ſummer.

In addition to the foregoing, I can aſſure you, on the moſt credible teſtimony, that there have been more inſtances than one of a pickerel's being caught in this river, at the ſeaſon of the coming of ſwallows, with one of thoſe birds in its belly.

I may poſſibly overrate theſe diſcoveries, yet, as I cannot overrate your candour, I hope to loſe no credit by communicating them to an old and faithful friend, who, though he ſhould not be informed, may poſſibly be amuſed by them.

I am, with the ſincereſt eſteem,

Sir, your moſt obedient ſervant.

SAMUEL DEXTER.

XXVI. *An Account of an Air-Pump on a new Construction; with some Observations on the common Air-Pump, and Mr.* SMEATON's *improvement: In a Letter from the Rev.* JOHN PRINCE *to the Rev.* JOSEPH WILLARD, *President of the University of* Cambridge.

Salem, Nov. 10, 1783.

REV. AND DEAR SIR,

AGREEABLE to your request, I will endeavour to give you some account of the air-pump I have lately constructed, upon a plan different from any I have ever seen.

Reading the account of the ingenious Mr. *Smeaton's* air-pump, in vol. xlvii. of the Philosophical Transactions, and the high recommendation of it by Dr. *Priestley*, in vol. lxiv. of the same work, I was desirous of possessing one of that kind: but finding, by the Doctor's paper, they were not commonly made by the philosophical instrument-makers in *London*, it induced me to attempt making one myself, with such assistance as I could get here.

Before I had proceeded far, I thought Mr. *Smeaton's* pump might be improved, if not in its power of rarifying the air, at lest in simplicity. With this in view, I have finished mine. To show the ground on which I have gone, it will be necessary to consider the rationale of an air-pump, and make some observations on Mr. *Smeaton's*. It is well known that the valve at the bottom of the barrel of an air-pump is opened by the spring of the air acting against it underneath, when the weight of the air is removed from the top of the valve, by raising the piston in the barrel. In order to remove this resistance from the top of the valve most effectually, the piston should be made to fit very exactly to the valve-plate, when put down upon it: for if there be any space between the bottom of the piston and

 valve,

valve, part of the air will be retained in it; and this air, even when the piston is raised to the highest, will, by its expansion, in some measure, obstruct the opening of the valve. When the air in the receiver, or underneath the valve, is rarefied to an equal degree with the air contained in the barrel, (the piston being drawn up to the highest) the valve can rise no longer, because the resistance above is equal to the power below. The resistance from this air, retained in the barrel, against the valve at the bottom, will be uniformly the same, when the piston is at the same distance from it; because the weight of the atmosphere is continually pressing on the piston-valve, and will prevent the air below passing through it, while this air is rarer than the atmosphere: and when the piston is put down to the bottom of the barrel, it will not escape through the piston, but only be compressed into the vacancy between the bottom of the piston and the valve-plate at the bottom of the barrel, and be of equal density with the atmosphere. Besides the resistance arising from this retained air, we must consider the weight of the valve, its cohesion to the plate, occasioned by the oil, and its being stretched tight over the hole, as increasing the obstruction; especially when the spring of the air under the valve is much weakened by rarefaction. And if we take into the account the resistance arising from these causes, the density of the air in the barrel, when compressed into the abovementioned vacancy, will be as much greater than the density of the atmosphere above the piston, as the addition of this resistance; for this obstruction belongs to the piston-valve, as well as to the other. And so also, when this retained air is expanded, say one hundred times, by raising the piston, the air in the receiver cannot be rarefied to the same degree, because of this resistance of the valve at the bottom of the barrel.

In

In order to produce a greater rarefaction of the air in the receiver than what the common pump will effect, the valves, where used, must be made to open easier, by removing, as far as possible, these obstructions. In the common pump these impediments are great; because the surface of the valve, which is exposed to the air underneath, is generally very small; and the vacancy between the piston and the bottom of the barrel bears a greater proportion to the whole barrel than it would if the work were properly executed.

These imperfections Mr. *Smeaton* considered and endeavoured to remove in the construction of his pump. For this purpose he exposed a much larger surface of the lower valve to the air underneath, by forming a kind of grating in the plate. By this the cohesion was lessened, and more power could apply to open the valve in the first instant. The difficulty arising from the air retained in the barrel he removed, in a great measure, by making the piston fit more nicely to the bottom, and by taking the weight of the atmosphere from off the piston, which allowed the valve in it to be more easily opened, so that much more of the air could pass through it. The weight of the atmosphere he removed from the piston, by closing the top of the barrel with a plate, on which he fixed a collar of leathers; through this the cylindrical part of the piston-rod moves air-tight. And the air, having passed through the piston, is forced out of the barrel through a hole in the top-plate, over which is a valve to prevent the return of air, when the piston descends. The piston is made to fit as exactly to the top, as to the bottom of the barrel, to exclude the air more effectually.

By this improvement, Mr. *Smeaton* says, " I have been able to " rarefy the air one thousand times, when the pump was put

" clean together; and that it seldom failed of doing it five hun-" dred, after it had been used for several months without clean-" ing: whereas the degree of rarefaction produced by the best " common pumps never exceeded one hundred and forty times, " when tried by my gage."

I have taken up much of your time in this account; but I hope you will not think unnecessarily, as it shows the ground on which I have gone, and a description of Mr. *Smeaton's* pump is, in some measure, a description of mine.

Mr. *Smeaton* having done so much to facilitate the opening of the valves, at the bottom of the barrel, and in the piston, by which means he carried the degree of rarefaction much further than the common pump could do; I supposed, if those valves were entirely removed, and the remaining air in the barrel could be more perfectly expelled, the rarefaction might be carried still further. Upon this plan I have constructed my pump. I have removed the lower valve, and opened the bottom of the barrel into a cistern, on which it is placed, and which has a free communication with the receiver. For the valve on the plate, at the top of the barrel, (which is constructed like Mr. *Smeaton's*) makes it unnecessary there should be any at the bottom, in order to rarefy the air in the receiver.

The cistern is deep enough to allow the piston to descend into it, below the bottom of the barrel. Suppose then the piston to be solid; that is, without a valve in it; when it enters the barrel and rises to the top plate, which is made air-tight with a collar of leathers, &c. like Mr. *Smeaton's*, it forces out all the air above it; and as the air cannot return into the barrel, on account of the valve on the top-plate, when the piston descends there will be a vacuum formed between that and the plate;

plate; every thing being fuppofed perfect. But in working the pump, the pifton is not allowed to defcend entirely into the ciftern, fo far as to leave the bottom of the barrel open; becaufe, as the ciftern, for another purpofe, is made larger than the bore of the barrel, this might make the pifton-rod work unfteadily in the collar of leathers, and caufe it to leak: but it defcends below a hole in the fide of the barrel, near the bottom, which opens a free communication between the barrel, ciftern, and receiver. Through this hole the air rufhes from the ciftern into the exhaufted barrel, when the pifton has dropped below it; and by its next afcent this air is forced out as the other was before. If now the capacity of the receiver, ciftern, pipes, &c. below the bottom of the barrel, taken together, be equal to the capacity of the barrel, half the remaining air will be expelled by every ftroke.

But as the working a pump of this kind, with a folid pifton, would be laborious, on account of the refiftance it would meet with in its defcent from the air beneath, (though this would be leffened by every ftroke, as the air became more rarefied) I have, to remedy this inconvenience, pierced three holes in the pifton, at equal diftances from each other; and a circular piece of bladder, which is tied over the top of the pifton, to make the joint more perfect with the top-plate, and to defend them from injury when the pifton is brought up againft it, forms a kind of valve over the holes, which opens eafy enough to prevent any labour in working the pump, as it allows the air to pafs through the pifton when it defcends. But the air does not neceffarily depend upon a paffage through the pifton in order to get into the barrel: for when the air becomes fo weak, from its rarefaction, that it cannot open this valve, it will ftill get into the barrel

rel when the communication is opened by the hole at the bottom. This piſton, therefore, will deſcend as eaſy as any other; and this valve does not impede the rarefaction; ſince it is of no conſequence, as to this, whether it open or not. By this conſtruction, the valves, which Mr. *Smeaton* only made to open with more eaſe, are rendered unneceſſary in rarefying the air: and that at the bottom of the barrel, which is the moſt difficult to be made and kept in order, is entirely removed; that on the top-plate being the only one neceſſary in rarefying the air.

But as in a ſingle barrelled pump of this conſtruction, where there is no valve at the bottom to prevent the air, which follows up the piſton in its aſcent, from returning into the receiver in its deſcent, a fluctuation would be produced, which might prove detrimental in ſome experiments, this pump is made with two barrels, which rarefies the air at every ſtroke of the winch. In this conſtruction, the capacity of the two barrels, taken together, below the piſtons, is always the ſame; for while one is deſcending, the other is aſcending; and what is taken from the one is added to the other.

Having thus ſet aſide the valves, which in ſome meaſure prevented the air from getting into the barrel and above the piſton, I next attempted to expel the air more perfectly out of the barrel than Mr. *Smeaton* has done, by making a better vacuum between the piſton and the top-plate, which would allow more of the air to expand itſelf into the barrel from the receiver. But to ſhow in what manner I have attempted this, it will be neceſſary to give ſome further deſcription of the machine.

I have, upon Mr. *Smeaton's* plan, contrived to connect the valves on the top-plates with the receiver, occaſionally, by means

means of a pipe and cock, by the turning of which, the machine may be made to exhaust or condense at pleasure. This is done in the following manner: There is a cross-piece laid over the valves, extending from one barrel to the other, which has a duct through it, connected with a small pipe standing between the barrels: through this pipe the air passes into a duct in the bottom-piece leading to the cock. In this piece is likewise the duct leading from the cistern to the cock; and with this cock also is connected the pipe leading to the receiver. The key is pierced with two holes in such a manner, that one of them will connect the pipe coming from the receiver with the duct in the bottom-piece leading to the cistern, or with the other leading to the valves, as may be required for exhausting, or condensing. The other hole through the key will open, occasionally, to the atmosphere, either of these ducts round the cock. So that having the direction of the air which passes through the valves, under the command of this cock, the pump may exhaust or condense at pleasure: for when the key connects the pipe from the receiver, and the duct leading to the cisterns together, the pump will exhaust; and when it connects the pipe with the duct leading to the valves, it will condense; as the other hole in the key, at the same time, opens to the atmosphere the duct leading to the cisterns, by which passage the air enters the barrel from the atmosphere, is forced out at the valves, and through the pipe and cock into the receiver. In this part of the machine which is contrived for condensation, I have, by an additional part, endeavoured to get the air more perfectly out of the barrel.

We have seen that Mr. *Smeaton*, by making the piston of his pump fit more exactly to the bottom of the barrel, and by shutting

ſhutting up the top to prevent the preſſure of the atmoſphere on the piſton-valve, was able to get more of the air above it than could be effected in the common pump. But ſtill the difficulty, though ſo far removed, remains in the top of the barrel: for as the piſton cannot be made to fit ſo exactly to the top-plate, but that there will be ſome lodgment for air, it is impoſſible to expel it entirely; more, perhaps, might be expelled if the valve on the top could be made to open more eaſily, by removing the weight of the air from it; for the atmoſphere, preſſing on this valve, will prevent its opening freely, in the ſame manner as when preſſing on the piſton-valve, it obſtructs the opening of that in the common pump.

The difficulty which Mr. *Smeaton* removed from the piſton-valves, I have endeavoured to remove from the valve on the top-plate; that this valve, having the preſſure of the atmoſphere taken off, might open with the ſame eaſe as the piſton-valve does in his pump. To effect this, there is connected with the duct on the bottom-piece, which conveys the air from the valves to the cock, a ſmall pump of the ſame conſtruction as the large one; having the barrel opening into a ciſtern, the piſton-rod moving through a collar of leathers, and a valve near the top, through which the air is forced into the atmoſphere. This piſton is ſolid; becauſe the diameter, being only half-inch, does not make it work hard. This pump, which is of one barrel only, I call the valve-pump; its chief uſe being to rarefy the air above the valves, or remove the weight of the atmoſphere from off them. To uſe this pump, it is neceſſary the key of the cock ſhould be pierced differently from that of Mr. *Smeaton's*; for as the pipes round his are placed at equal diſtances, when the one from the bottom of the barrel is connected

with

with that from the receiver to exhaust it, the other, from the valve on the top-plate, is opened to the atmosphere by the other passage through the cock. But in order to rarefy the air above the valve in my pump, it is necessary this last passage should be shut up, when the valve-pump is used. Instead, therefore, of placing the three ducts at equal distances round the cock, I have divided the whole into five equal parts; leaving the distance of one-fifth between the ducts leading from the cistern and the valves to the cock, and two-fifths between each of these and the one leading from the cock to the receiver. By this adjustment, when the communication is open between the receiver and valves, for condensation, the other hole through the cock opens the cisterns to the atmosphere: but when the communication is made between the cisterns and the receiver, for exhaustion, a solid part of the key comes against the duct leading to the valves, and shuts it up; and the air, which is forced out of the barrel, passes into the atmosphere through the valve-pump; for the valve of the small pump may be kept open while the great one is worked.

Now, to apply Mr. *Smeaton's* reasoning to this construction. After mentioning his taking off the weight of the atmosphere from the piston, by shutting up the top of the barrel, he says, "The consequence of this construction is, that when the piston is put down to the bottom of the cylinder, the air in the lodgement under the piston will evacuate itself so much the more, as the valve of the piston opens more easily, when pressed by the rarefied air above it, than when pressed by the whole weight of the atmosphere. Hence, as the piston may be made to fit as nearly to the top of the cylinder, as it can to the bottom, the air may be rarefied as much above the piston

" as it could before have been in the receiver. It follows, " therefore, that the air may now be rarefied in the receiver, " in duplicate proportion of what it could be upon the com- " mon principle ; every thing else being supposed perfect." The same may be said with regard to the valve on the top-plate in this machine. It will open more easily, when pressed by the rarefied air above it, than when pressed by the weight of the whole atmosphere. Hence, as by the construction of the valve-pump the air may be rarefied as much above the valves, as it could before have been in the barrel and receiver, with which there is a free communication : it therefore follows, that the air may now be rarefied in the receiver in duplicate proportion of what it could be by Mr. *Smeaton's* pump ; every thing else being supposed perfect ; and the nature of the air permitting it.

In this estimation, any advantage which may arise from the removal of the valves at the bottom of the barrels and in the piston, is not considered : But if they made any resistance in Mr. *Smeaton's* pump, may we not conclude, that the rarefaction might be carried further by a machine wherein no such valves are made use of ? Mr. *Smeaton* says, that when he contrived to open his valves by the winch, independent of the spring of air, he did not find it answer the purpose better than when the air was the agent. There is no reasoning against experiment : but it certainly appears probable from theory, that there must be considerable resistance from the valves when the air is greatly rarefied.

He afterwards says, " the degree, to which I have been able " to rarefy the air, by experiment, has generally been about one " thousand times, when the pump is put clean together : but

" the

" the moisture that adheres to the inside of the barrel, as well
" as the other internal parts, upon letting in the air, is, in the
" same succeeding trials, worked together with the oil, which
" soon renders it so clammy as to obstruct the action of the
" pump, upon a fluid so subtle as the air is, when so much
" expanded.—But in this case it seldom fails to act upon the
" air in the receiver, till it is expanded five hundred times: and
" this I have found it to do, after being frequently used for several
" months without cleaning." Does it not appear probable, that this clamminess must have a bad effect upon the valves, as well as the other internal parts of the pump, in those same succeeding trials? and that the stiffness which the oil acquires by evaporation, the corrosion of the brass, &c. when the pump is foul, must greatly obstruct the opening of the valves, and bear a principle part in reducing the rarefaction from one thousand to five hundred times?

I supposed the valves to be a great obstruction, and have endeavoured to avoid them: and if no further advantage be derived from it, the machine is more simple without them.

Upon this construction, also, we are able to make the pump with two barrels, like the common pump, which cannot be done conveniently where the lower valve is retained; because it would be difficult to make the piston in one barrel come exactly to the bottom, at the same time that the piston in the other touched as exactly at the top: it would, at least, require a nicety in the workmanship, which would be troublesome to execute.

In this pump, the pistons do not move the whole length of the barrels: there is a horizontal section made in them, a little more than half way from the bottom, where the top-plates are

 inserted

inserted. By this mean the pump is made more convenient and simple, as the head of it is brought down upon the top of the barrels, in the same manner as in the common air-pump. The barrels also stand upon the same plane with the receiver-plate; and this plane is raised high enough to admit the common gage of thirty-two or three inches, to stand under it, without any inconvenience in working the pump, as the winch moves thro' *a less* portion of an arch, at each stroke, than it would if the pistons moved the whole length of the barrels.

There is also placed, between the barrels in this pump, on the cross-piece over the valves, a gage to measure the degree of condensation, having a free communication with the valves, cock, &c. This gage is so constructed, that it will also serve to measure the rarefaction above the valves, when the air is worked off by the valve-pump. It consists of a pedestal, which forms a cistern for the mercury, a hollow brass pillar, and glass tube, hermetically sealed at one end, which moves up and down in the pillar, through a collar of leathers. The dye of the pedestal is made of glass, as well to hold the quicksilver, as to expose its surface to view, that it may be seen when the open end of the tube is put down into it, or raised out of it. The body of the pillar is partly cut away to expose the tube to view in the same manner.

If the pump be used as a condenser, the degree of condensation is shown by a scale marked on one edge of the pillar: if it be used as an exhauster, the degree of the rarefaction of the air, above the valves, is shown by a scale marked on the other edge of the pillar.

This gage will also serve to show when the valves have done playing, either with the weight of the atmosphere on them, or

or taken off. If we want to know when they cease opening, with the weight of the atmosphere on them, draw the piston of the valve-pump up into its barrel, to prevent any air escaping through that valve; in this situation, work the great pump again, and if any air passes through the valves into the pipe, the gage will rise by condensation. This condensed air must then be let out by opening the communication, at the cock, with the outward air. By repeating this till the gage rises no longer, we may know the valves will open no more while the weight of the atmosphere lies on them; and the rarefaction in the receiver can be carried no further. When the weight of the atmosphere is to be removed, after conducting as in the former experiment, raise the open end of the tube above the surface of the mercury, and then work the valve-pump, and the air will be rarefied over the valves, and in the tube, to the same degree: (we may see when the valve of this pump has done playing by unscrewing the cap that covers it.) The open end of the tube is then to be immersed into the mercury, and the great pump worked. The air which passes thro' the valves will then raise the gage by condensation: and thus, by alternately raising and depressing the tube, and working the two pumps in their turns, we may carry the rarefaction of the air in the receiver as far as the power of the pump will go. If one of Mr. *Smeaton's* pear-gages be used in the receiver, as he directs, the difference of the rarefaction, in the two experiments, may be known. And as the air above the valves may be rarefied to different degrees, we may know, by the two gages, what proportion the rarefaction above the valves bears to the degree of excess in the receiver. This condensing gage can be taken off, and a button screwed into the hole in its stead, in any case wherein a greater degree of condensation is required than the

the glaſs will bear. When a glaſs receiver is uſed, this gage may be placed within it, where it will meaſure any degree of condenſation the receiver will bear, without danger to the gage: or the capacity of any receiver may be meaſured by this gage, before it is removed from its place, by ſhowing how many ſtrokes of the winch will throw one atmoſphere into the receiver; then turning the cock, to prevent any air eſcaping, change the gage for the button: when this is done, the degree of condenſation may be further meaſured by the number of ſtrokes.

As in caſes where great condenſation is required, there muſt be a great deal of labour, and a great ſtrain on the teeth of the wheel and piſton-rods, on account of the great diameter of the piſtons; * to remedy this, I have fitted a condenſer, of a ſmaller bore than the barrel of the great pump, to the ciſtern of the valve-pump, to be ſcrewed on occaſionally; by which the condenſation may be finiſhed, inſtead of the great pump. Or, to ſave the work and expence of this condenſer, the valve-pump, if made a little larger, may be eaſily fitted for the ſame purpoſe, by having a plate made to ſcrew into the bottom of the cylinder, occaſionally, with a valve on it, opening into the ciſtern: a hole muſt alſo be made to be opened, on the ſame occaſion, near the top of the cylinder, to let air in below the piſton, when this is drawn up above it.

The common gage, which is generally placed under the receiver-plate, in this pump, is placed in the front; that it may be ſeen by the perſon who is working the pump, and that the plate may be left free for other uſes.

The

* In my pump, the piſtons are two inches diameter; ſo that there will be about forty-eight pounds added to the reſiſtance in opening the valves, for every atmoſphere thrown into the receiver.

The plate is so fixed to the pipe, leading to the cock, that it may be taken off at pleasure, and used as a transferer; or any tube, or apparatus, may be fixed to it, to perform some experiments without removing it, which will save trouble, and make less apparatus necessary.

The head of this pump is not divided, as the common one is, to dislodge the teeth of the wheel from the piston-rods, when the pump is to be taken apart; but is made whole, except a small piece in the back, where the wheel is let in; which makes it much more convenient to remove the head, or place it on the barrels. The wheel is freed from the piston-rods, when required, by pushing it into the back part of the head; and when it is drawn into its place and connected with them again, a button is screwed into the socket of the axis behind, to keep it in its place. This makes the head less troublesome to remove: but its chief use is to dislodge the piston-rods from the wheel, that they may be put down into the cisterns, when the pump is not in use, where they will stand uncompressed, and retain their elasticity better than if kept in the barrels. In these cisterns they may also stand covered with oil, if necessary, as they are large enough to admit of it.

The principal joints of the pump are sunk in sockets, that the leathers, which close them, may be covered with oil, to prevent leaking.*

For convenience, the lower part of the pump is fitted with drawers, to contain the apparatus. A door opens behind one range

* This, I find, is very effectual; having never known one of the joints, secured in this way, to leak, though the pump has stood for a long time: whereas a portable pump which I have, made by Mr. *Nairne*, *London*, has leaked, and repeatedly been refitted with new-oiled leathers, in the same time.

range, to a place reſerved the whole height, to get at the under part of the receiver-plate, and fix apparatus to it for ſome experiments. In this place ſtand the long tubes, and ſuch tall glaſſes, belonging to the apparatus, as will not go into the drawers. The barrels, &c. of the pump are covered with a caſe, or head, which keeps them from duſt and accident, when the pump is not in uſe. The apparatus is ſecured between ſliders, &c. in the drawers, ſo that the whole machine may be eaſily removed, in one body, without danger.

Having given you this account of the machine, I wiſh, Sir, I could add to it, at this time, the reſult by experiment, and inform you to what degree it will rarefy the air; but the want of a proper apparatus to meaſure the rarefaction, prevents me.

As we have no glaſs-manufactory here, I ſent to *Europe* for my apparatus, about twelve months ſince: but, unluckily, this part, with ſome others, have not yet been forwarded to me. As ſoon as I can ſatisfy myſelf, I will let you know the reſult. I have, at preſent, only a ſmall tube of two-tenths inch bore, I accidentally met with, which I uſe as a common gage: but this will not determine the power of the pump.

All I can ſay of the inſtrument at preſent is, that I find it much more convenient to uſe than one of the common ſort: that it will exhauſt a receiver much ſooner, and keep in order much longer, for being made without valves, which muſt depend on the ſpring of the air to open them. When a common pump, which I have, has been fitted up with valves, leathers, &c. at the ſame time with this; the valves of the common pump have become too dry and ſtiff to uſe, while this pump has continued in good order. I attribute this, in part, to the moiſture which the valves on the top-plates receive from the

piſtons

piſtons every time the pump is uſed ; the piſtons being always kept moiſtened with oil in the ciſterns, where they ſtand when the pump is not in uſe ; and in part, to the power which the piſtons have over theſe valves, by condenſing the air againſt them. In the common pump, and in Mr. *Smeaton's*, the valves, at the bottom of the barrels, can only be opened by the ſpring of the air acting againſt them : but in this pump the valves are forced open, by raiſing the piſtons, and muſt, therefore, yield much longer to the power applied in this way.

I mentioned above, that the piſtons in this pump did not move the whole length of the barrels ; but were interrupted by the plate, a little more than half way from the bottom, for convenience : but on this conſtruction, they may be made to move through the whole length, as in Mr. *Smeaton's* pump ; and then it will exhauſt a receiver in half the time that his will, if the capacity of each barrel in the two pumps be equal. And perhaps the air may be further rarefied by a pump on this conſtruction without the valves, whoſe barrels are of greater length than the barrels of my pump. For ſince the piſton may be made to fit as well to the top of one barrel as another, if the length of the barrel, through which the piſton moves, be twelve inches inſtead of ſix, the vacancy, which is unavoidably left between the top-plate and the piſton, when the latter is drawn up to the former, will bear a leſs proportion to the capacity of the whole barrel. Suppoſe, then, the valve on the top-plate will riſe only till the air be expanded one hundred times in a barrel of ſix inches length, becauſe this is the proportion which the vacancy bears to the capacity of the whole barrel, (the reſiſtance of the valve not being taken into the account) it will riſe till the air is expanded two hundred times in a barrel of twelve inches

length, the diameters being the ſame in both, becauſe the capacity of the barrel being doubled, the vacancy bears ſo much leſs proportion to it than to one of ſix inches. And if the air can be rarefied in proportion to the difference between the vacancy and the capacity of the barrel, by leſſening this proportion, which, after having made the work to fit as well as poſſible, is to be done by enlarging the capacity of the barrel, the power of the pump muſt be increaſed.

This, Sir, is reaſoning from theory: but theſe circumſtances, I think, ought to be conſidered in the conſtruction of an air-pump; and experiment only muſt determine how far an attention to them may be uſeful.

The rarefaction which a pump will produce, by experiment, may come very far ſhort of what it ought to do by the theory of its conſtruction. If the common pump will, in experiment, rarefy the air only one hundred times, when in its beſt ſtate, and Mr. *Smeaton's*, by conſtruction, in duplicate proportion to this, it ought to go to ten thouſand; every thing being ſuppoſed perfect: but in its beſt ſtate, Mr. *Smeaton's* pump will only rarefy the air about one thouſand times; ſo that the nine-tenths which it falls ſhort of what it ought to do by theory, is to be attributed either to the imperfection of the machine alone, or to the nature of the air, in not permitting the rarefaction to go further than one thouſand times, or both theſe cauſes together. The way to prove how far this is owing to the air itſelf, is by making a machine, which, in theory, will carry the rarefaction further. A pump conſtructed without the valves, as mine is, ought to rarefy the air in duplicate proportion of what Mr. *Smeaton's* ſhould do by theory, and in quadruplicate proportion of the common pump, which would be one hundred million,

allowing

allowing the common one to rarefy the air one hundred times. Nothing like this, however, is to be expected, since we see Mr. *Smeaton's* pump, in experiment, falls so far short of the theory. But supposing my pump to rarefy the air in duplicate proportion of what Mr. *Smeaton's* does by experiment, this would carry the rarefaction to one million times: and whatever it falls short of this, must be attributed either to the imperfection of the machine, or the nature of the air, or both together: or if this pump should rarefy the air only to the same degree with Mr. *Smeaton's*, since by construction it ought to go so much further, will it not ascertain to us, in a direct line, that the nature of the air does not admit of being further rarefied by a pump; and that this is the reason why Mr. *Smeaton's* pump, in experiment, fell so far short of the theory? If this should be the case, will it not be a confirmation that the power of mechanism is not wanting to produce a much greater rarefaction in the receiver, where no body acts immediately upon the air to expel it, and from which place it can only be induced to come, by making room for its expansion into some other? I hope, in a little time, to be able to inform you what the result is by experiment, and to what degree this pump will exhaust the receiver.

I am, &c.

JOHN PRINCE.

NOTE. Since this letter was communicated, I have seen, in the 67th vol. of the Philosophical Transactions, an account of some experiments made by Mr. *Nairne*, with a pump constructed on Mr. *Smeaton's* principle: from which it appears that Mr. *Smeaton* was deceived with respect to the rarefaction in his receiver, as indicated by the pear-gage; and that the greatest power of the pump, when the experiment was properly made, would carry the rarefaction in the receiver only to six hundred, instead

AN EXPLANATION OF THE PLATES.

PLATE IV. Fig. 1. A view of the pump ſhut up, when not in uſe; appearing through a glaſs window, as ſhewn by the pricked lines.

Fig. 2. A view of the pump when opened and uncovered for experiments.

Fig. 3 A perpendicular ſection of one of the barrels, the two ciſterns, condenſing gage, &c. where A B repreſents the barrel: C D the ciſtern on which it ſtands; *a a a a* the leathered joint, ſunk into a ſocket, and buried in oil: E F is the piſton; the cylindrical rod paſſing through a collar of leathers, G G, in the box H I. K ſhows the place of the valve on the top-plate K L, covered by the croſs-piece M M, into which the pipe O O is ſoldered; that conveys the air from the valves to the duct going under the valve-pump, as may be ſeen in plate V. fig. 1. *o* is part of the ſaid duct; *p* is the joint ſunk into a ſocket in the croſs-piece P P, which connects the ciſterns and has a duct through it leading to them. Into this duct open the ducts *q* and *r*, the firſt leading to the gage in front of the pump, the other to the cock and receiver.

of one thouſand times. By an account of Mr. *Cowallo's*, in the 73d vol. of the Philoſophical Tranſactions, I find an improvement made in Mr. *Smeaton's* pump, by Mr. *Haas*, inſtrument-maker. He has contrived to open the valve at the bottom of the barrel independent of the ſpring of the air underneath; and by this improvement he has increaſed the power of the pump to one thouſand times. This experiment is a confirmation of what is to be expected from the removal of the valve in my pump, which is done with greater ſimplicity, as Mr. *Haas's* contrivance is complex, conſiſting of a ring lying at the bottom of the barrel, to which ring the valve is faſtened; this ring is raiſed by a pedal, connected with two wires moving through two collars of leathers, and is depreſſed by a ſpiral ſpring contained in a ſocket, the whole being fixed under the barrel of the pump: But he has done nothing to remove the reſiſtance from the valve in the piſton, nor the weight of the atmoſphere from off the valve on the top-plate.

The other barrel is left out of the figure, to show some of the parts more distinctly; except Q Q, which is the top of the barrel retained and brought down out of its place, to show the top-plate, that shuts up the barrel, separated from the box, which contains the collar of leathers. S shows one of the holes in the plate over which the valve lies, and which is covered by R in the cross-piece. V V is the piston showing the valve open on the top, which is to prevent labour when the pump condenses. W X is the cistern, in which is more distinctly seen the shoulder for the leather which closes the joint between this and the barrel, and also the socket in which the oil lies over the leather. Y Z is the condensing gage, with the orifice of the tube raised above the surface of the quick-silver. *e e* is the collar of leathers, through which the glass tube moves. *i* is a small pipe coming up through the quick-silver to make a communication between the valves and the gage.

Fig. 4. is a view of the upper surface of the top-plate which closes the barrel, being soldered into it, showing the place of the valve over the three small holes, one of which only can be seen at S, in fig. 3.

Plate V. fig. 1. is a perpendicular section of the bottom-piece, pipes, valve-pump, cock, &c. at right angles with the other section, fig. 3. pl. IV. A B is the pipe between the barrels, as represented in plate IV. The button *o* is here screwed into the top instead of the gage. C D is the valve-pump and its cistern, *e* the place of the valve under the cap. E F the cock, showing the duct through it leading to the atmosphere. G H the pipe leading from it to the stem of the receiver-plate, in which is the cock I, to shut up the duct when the plate is used as a transferer. K K is the plate. L a piece to shut up the

the hole into which tubes, &c. are occasionally screwed to perform experiments without removing the plate: the pricked line at O shows the place of the screw which presses the plate against the pipe: P Q the pipe and common gage standing in front of the pump.

Fig. 2. is a horizontal section of the cock and pieces, containing the ducts leading from it to the receiver, the cisterns, and the valves on the top of the barrels. A B the duct connecting the cisterns together. C D the duct leading from the cisterns to the cock. G H the duct leading from the cock, through the pipe A B, (fig. 1.) to the valves. D E the duct through the cock, which occasionally connects the two last-mentioned ducts with the duct E F, leading from the cock to the receiver. I the duct in the cock leading to the atmosphere, which, when connected with the duct at D, lets the air into the cisterns and barrels for condensation; the other duct through the cock at the same time connecting H and E. This duct also, when connected with E, restores the equilibrium in the receiver. K L is part of the duct leading from the cisterns to the gage. The pricked circles show the places of the pipe and valve-pump on the piece, and *r* the place where the air enters the valve-pump from the duct G H, and is thrown into the atmosphere, when the pump exhausts.

Fig. 3. shows the under surface of the boxes, which contain the collars of leathers, with the cross-piece, which connects them together, having a duct through it, as represented by the pricked line, through which the air passes from the valves to the pipe: this fig. is designed chiefly to show the places in which the valves play, as at I.

Fig.

Fig. 4. is a ſide view of the pump, ſhowing the ſituation of the valve-pump and handle of the cock; where A is the pump, and B the handle.

Fig. 5. is the top-plate which ſcrews the key of the cock into its ſhell, and keeps it tight: the upper ſurface of it is marked with directions to turn the key ſo as to produce the effect deſired: for when the mark on the key agrees with the mark on the plate, the pump exhauſts, and ſo of the reſt.

XXVII. *A Deſcription of a Pump-Engine, or an Apparatus to be added to a common Pump, to anſwer the Purpoſe of a Fire-Engine; invented by Mr.* BENJAMIN DEARBORN: *Extracted from his Letters to the Hon.* JAMES BOWDOIN, *Eſq; Preſident: communicated by the Preſident.*

Portſmouth, *November* 5, 1781.

SIR,

I HAVE ſpent ſome time in inventing the pump-engine, a model of which I have forwarded herewith. This engine is deſcribed as follows.

Plate VI. Fig. 3. A B C D repreſents a pump in the form of a common ſhip-pump. E its ſpout. F a ſtopper. D *d* is a plank cap, fitted with leather under it to the pump, and ſcrewed down by the ſcrews *a b*; having a hole in the center for the ſpear of the pump to paſs through, round which a leather collar is made, as *c*. *g* is a nut for the ſcrew *b*. *f b* is a ſquare piece of wood, nailed acroſs one end of the cap, the ſcrew *a* paſſing through it and the cap; through this piece and the cap a hole is made, communicating with the bore of the pump. G G is a wooden tube (of any required length or number of joints) made ſquare at the lower end, and hollowed to receive the cock, the upper end being made with a nice ſhoulder. *e* is a wooden cock, which opens or ſhuts the communication between the pump and the tube, having a handle on the oppoſite ſide, with a lock if neceſſary. *h h* are ferrules to prevent the tube from ſplitting. H H are braces, each of which muſt have another croſſing it as nearly at right angles as may be. *i i* are irons in the form of a ſtaple, going round the tube and through the braces, having holes in their ends for forelocks. K L M N is a head made of five pieces of wood, viz.

k l m n

k l m n, a ſquare piece, with a hole in the lower end, to receive the end of the tube, and reſts on the ſhoulder *o p*; on the lower end of this head a leather is nailed, having a hole in its centre ſimilar to the hole in the wood; another leather of the ſame form is put on the top of the tube, and a circle of thin plate-braſs between them; the two leathers and the braſs being preſſed between the lower end of the head and the ſhoulder of the tube; their edges are repreſented by *o p*. K N and L M are the edges of two pieces of plank which are as wide as the head, and nailed faſt to it, each of them having a tennon going through a mortice in the end of the piece O P; each tenon has a hole for a forelock at *q q*. O P is a piece of plank as wide as the ſides, having a hole in its centre through which the tube paſſes, and a mortice on each end for the tennons to paſs through. N M is a cap. *r r* are two pieces nailed on the ſide of the tube, with a truck in the lower end of each, to leſſen the friction of the head in its horizontal revolution. *q q* are forelocks to wedge the head down, and prevent the water from finding a paſſage out at the joint *o p*. Q R is a wooden conductor; the end Q being ſolid, the end R bored with a ſmall auger, *s* is a bolt going through the conductor and head, ſecured on the back with a forelock or nut; this bolt is round near the head and ſquare in the middle. *t u w x* is a piece of iron or braſs to prevent the head of the bolt from wearing into the wood. S S are ropes to direct the conductor.

Fig. 4. is the head without the conductor; *a b c d* is a thick braſs plate perforated to prevent dirt from cloging the conductor, and nailed with leather under it to the head. The ſquare hole in the centre is made to the ſize of the bolt, and prevents it from turning. The conductor has a hollow cut

S ſ ſ round

round the bolt on the inside, as large as the circle of holes in the brass, round which hollow on the face of the conductor, a leather is nailed which plays on the margin of the brass plate, when the conductor turns.

I have raised a tube of 30 feet on my pump, but the severity of the season prevents my compleating it; having so far executed it only, as for one person to work at the brake; I can myself throw water on the top of a neighbouring building, the nearest part of which is 37 feet from the pump, and between 30 and 40 feet high.

XXVIII. *A Description of a Fire-Engine of a new Construction, by the same. Extracted from a Letter to the same.*

Portsmouth, *January* 28, 1782.

S I R,

HAVING constructed a model of a portable fire-engine, on the same principles as the pump-engine, I do myself the honour to forward you a description of it.

Plate VI. Fig. 1. A B and C D are the edges of two planks, confined together by four bolts. *a b c d* are two cylindrical barrels: in each of these barrels a piston with a valve is fastened to the spear *e*, and is moved up and down alternately by the motion of the arms E E. Under each barrel a hole is made through the plank A B, and covered with a valve. E E are arms hung on the common centre *f*. Arms parallel to these are on the opposite side. *g* is the end of a handle which is fastened across the ends of the arms. A bolt at *h* goes across from arm to arm; to this bolt the piece *i k* is fastened, and plays upon it; the lower end of this piece is fastened to the top of the spear *e*. G *l f* is a standard to support the arms; another answering to it on the opposite side, both being notched into the edges of the planks, are sufficiently secured by one bolt going through them at *l*, and having a nut or forelock on the opposite side. H I H I are square braces, which answer the purpose of ducts, through which the water ascends from the barrels through the plank at *m*. K L K L are irons in the form of a staple to confine the braces; the lower ends of these irons meet, and are secured with one bolt going through them and M N *n o*, which is a piece going up through a mortice in the centre of the planks; this piece is square from the lower end upward as high as the top of the braces; from thence to the top it is cylindrical; the

upper end being bored hollow, far enough down to communicate with the braces. O P is an iron ring going round the tube, having two ſhanks going up through the head, with ſcrews on the top at *p q*. *r s* is a ferrule nailed round the tube. The head and pipe are ſo nearly ſimilar to thoſe of the pump-engine that they need no further deſcription.

Fig. 2. is the ſame engine; the arms and ſtandards being taken off to give a more intelligible deſcription of the mode of ſecuring the braces, which is effectually done by one wedge driven into the mortice *a*, under the upper plank. *b* is a hole for the bolt to paſs through which ſecures the ſtandards. In this figure a ſide view of the head is given, with the pipe in a perpendicular direction.

The work is confined within a box ſet on wheels as common. The whole is made of wood except the ſpears of the pumps and a few bolts, &c. This model throws water about the ſame diſtance as the miniature pump-engine, the pumps being of the ſame bore. Engines on this conſtruction may be made in any place where a common pump can; and the inſide work will not be more than one quarter the coſt of thoſe on the uſual conſtruction; and the labour of working them will (as I conceive) be much leſs than in the others; theſe conſiderations may perhaps recommend them to ſome attention.

XXIX. *Obſervations upon the Art of making Steel. By the Reverend* DANIEL LITTLE, *F. A. A.*

AS ſteel is an article of commerce, and of great uſe both in the arts, manufactures and huſbandry of every nation; and as we have the beſt of iron already manufactured in *America*, it is thought that the manufacturing of ſteel of a good quality, deſerves the attention and encouragement of thoſe who wiſh the welfare of the United States. What time I could redeem from other neceſſary buſineſs for ſeveral years paſt, has been employed in ſuch diſquiſitions and experiments, as might tend to facilitate the art of making ſteel, and others near akin to it.

Thoſe writers upon the ſubject which I have met with tell us, that the principal difference between iron and ſteel conſiſts in this, That the latter is combined with a greater quantity of phlogiſton than the former. Phlogiſton exiſts in all inflammable ſubſtances, and in ſome that are not inflammable. Charcoal, and the coals of bones, horns and hoofs of animals, have been uſed as fit ſubſtances for communicating phlogiſton to iron in making ſteel.

Steel is ſometimes made by fuſion of ore or pig-iron. The method is ſimilar to that of reducing pig-iron to malleable iron, with this difference, that as ſteel requires more phlogiſton than is neceſſary to iron, all the means muſt be made uſe of that are capable of introducing into the iron a great deal of phlogiſton; that is, by keeping it, while in fuſion, encompaſſed with an abundance of charcoal, &c.

The other method of making ſteel is by cementation, as it is called; that is, to convert bar-iron into ſteel; which is done by a cement made of thoſe ſubſtances which contain the greateſt quantity of phlogiſton. Put the bar-iron with this cement in-

to

to a vessel that will bear a strong fire; lute on a close cover, so as to prevent the cement taking flame and consuming; put the vessel in a furnace where the bars may be kept red-hot till they are converted into steel, which will be in a longer or shorter time, according to the bigness of the bars, and the quantity of cement.

This latter method has chiefly engaged my attention, which method is pretty well known in some parts of *America*, and, for many years past, steel has been made by it in several of the United States. Yet, so far as I have been informed, it has generally been of an inferior quality, and very little used for edge tools, which I supposed could not arise from the quality of the iron, for we have the greatest variety, and the best sort, in many parts of the country. I then conjectured there might be found some other inflammable substance for a cement, which, if properly applied, would impregnate the iron with phlogiston more advantageously. And, after many experiments, I found a particular marine plant that requires no other preparation but drying and pulverizing, and is commonly known by the name of rock-weed, or rock-ware, and is in the greatest plenty on our rocky shores, coves, creeks and harbours of the sea. In making some experiments upon this plant for a flux powder, a small bit of iron was put into a crucible, and filled with the said cement; and, very unexpectedly, after it had been in a little more than a cherry heat for five or six hours, it was converted into steel, which gave me the first hint of its use in making steel; since which I have had repeated experience of its excellency for the same purpose.

It needs no other preparation than to be cut off from the rocks with a scythe or sickle, spread on the dry land 'till the rains have washed

waſhed off the greater part of the ſea-ſalt, then dried and pulverized, then uſed as other cements are in making ſteel: or, inſtead of waſhing off the ſea-ſalt, it is better for ſome particular kinds of iron, to neutralize it by adding a fixed alkali.

To two parts of the plant well dried and pulverized, add one part of good wood-aſhes; mix together and moiſten the whole with water or rather urine to the conſiſtence of a very thick paſte.

It is well known that in every new art, and in perfecting old ones, many unforeſeen difficulties ariſe, and ſometimes conſiderable fortunes have been ſpent before the manufacturer or the public have been much benefited. And ſince honeſt, but too credulous minds are often deceived by uncertain proof, and being willing to ſatisfy myſelf and others, by a better teſtimony than my own, I engaged a * gentleman of ability in the ſteel way for many years, whoſe furnace was complete and large, to make experiments upon my new diſcovered ſubſtance for a cement, who has written me, that "this ſteel is preferable to any he had ever made before." After all, I ſuppoſe different modes of preparation and further experiments will more fully aſcertain its utility.

The matter of the furnace muſt be of ſuch ſubſtances as will endure a ſtrong fire without fuſion. Aſbeſtos has been uſed to advantage, but a ſufficiency of it is not found in many places. Pipe-clay with one third part of pond-ſand, or, which is better, white ſtones free from grit, well burnt, and pulverized, inſtead of ſand, ſome ſpecies of ſlate and talc may be uſed with pipe-clay for furnaces and crucibles.

The cheſt or interior part of the furnace, for depoſiting the cement and bars of iron, muſt be covered ſo cloſe that the inflammable ſubſtance within may not be conſumed, but changed like

* Col. *Eliot* of *Connecticut*.

like wood in a coal-kiln. The iron to be choſen of the beſt quality; its toughneſs and malleability are marks of choice.

Of the ore of iron.—This is often diſcovered by the magnet, but a great part of the beſt ore is that which the magnet will not attract, as *Linnæus* and *Macquer* juſtly obſerve. When in that ſtate it often reſembles the ruſt or calx of iron. Many tuns of which are brought to the iron-works in this neighbourhood, from which the beſt of iron is made. In its natural ſtate the beſt magnetic bar will not attract the ſmalleſt particle; but when roaſted with charcoal it becomes magnetic. This method of knowing whether any earth or ſtones contain the true ore of iron, may be of uſe to diſcover new bodies or beds of ore. The reduction of metals, or reſtoring them to their metalic ſtate from their calces, by combining them with the inflammable principle in the application of charcoal, may ſufficiently ſhow the efficacy of the above method for the diſcovery of the earth of iron in thoſe ſubſtances on which the magnet has no effect.

PART III.

MEDICAL PAPERS.

I. *An Account of the Horn-Diſtemper in Cattle, with Obſervations on that Diſeaſe. By the Hon.* COTTON TUFTS, *M.D. F.A.A. and M.S. In a letter to the Rev.* JOSEPH WILLARD, *Cor. Sec. A.A.*

BEASTS of the foreſt, guided by the dictates of nature, and uncontrouled by man in their food, air, exerciſe and reſt, are ſeldom affected with any diſeaſe, whilſt in almoſt all countries, the domeſtic kind, that are more immediately under the government of man, are ſubject to a variety.

Scarcely an inſtance in this country of reigning ſickneſs among tame or wild beaſts, has been noted by its hiſtorians; and it is within thirty years that we have heard much of epidemic diſeaſes among either.

About twenty-five years paſt an epidemic diſtemper prevailed among dogs, and occaſioned a great mortality. In 1768 horſes were generally affected with a diſorder of the head and throat, which proved fatal to many, and much injured the ſerviceableneſs of thoſe that ſurvived. About the year 1770, there were ſome inſtances of the *rabies canina*; happily but few dogs were affected, and but few perſons were bit; their rage principally fell upon ſwine. In 1771, a mortal diſtemper prevailed among foxes, and greatly reduced their numbers: about this

time

time, or not long after, a diſtemper appeared among neat cattle, which deſtroyed many, and has continued to this day. The diſtempers that befel theſe ſeveral kinds of animals, were ſaid not to have been known in the country before, more eſpecially that which has affected neat cattle, and which has generally been conſidered as a new diſeaſe: Some, however, have ſuppoſed it to be the ſame, which from time to time has made ravages in *Europe*, and more eſpecially in *England*. Whether it was ever known there is uncertain. It evidently differs from thoſe which *Engliſh* writers have mentioned as proving fatal to their cattle. The compilers of the complete body of huſbandry, republiſhed in 1768, make no mention of this diſorder, though they have treated largely of the diſorders of horn-cattle; thoſe that have been more eſpecially prevalent, and have proved mortal, they have deſcribed under the names of *gargil*, *garget* and *murrain*, and as attended with external ſwellings, inflammations, eruptions, and contagion, and add, that "the *murrain* is the diſtemper now, and of many late years, ſo fatal among the horn-cattle." In 1757, *Daniel Peter Layard*, M. D. F. R. S. publiſhed a particular account of the nature, cauſes and cure of the diſtemper then among the horn-cattle in *England*. He conſiders it as an eruptive diſeaſe, in the ſeveral ſtages, progreſs and effects of it, exactly the ſame with the ſmall-pox, and earneſtly recommends inoculation. None of the external ſwellings, eruptions or contagion, characteriſtic of theſe diſorders, and to which ſwine and ſheep, as well as neat cattle of all ages and kinds, are incident, are peculiar to this diſorder. It is commonly called the horn-diſtemper: Cows are more eſpecially ſubject to it; oxen but ſeldom,—bulls are ſaid to be exempt from it, alſo ſteers and heifers under three years of age. It is a diſeaſe that affects

affects the internal substance of the horn, commonly called the pith, insensibly wastes it, and leaves the horn hollow. The pith is a spongy bone, whose cells are filled with an unctuous matter; it is furnished with a great number of small blood vessels, is overspread with a thin membrane, and appears to be united by suture to the bones of the head, and is projected to a point. In a healthy beast it fills up the cavity of the horn, the horn itself being a sheath or case giving firmness, and the whole serving as a weapon of defence.

This spongy bone, in the horn distemper, is sometimes partly and sometimes entirely wasted. The horn looses its natural heat, and a degree of coldness is evident upon handling it; when it is only in one horn, (which is often the case) a manifest difference between the one and the other will be perceived, and in all cases a want of natural heat will be apparent; wherever this is found, there is no room to doubt of the disorder's being present; yet it is seldom suspected without a particular acquaintance with other symptoms that commonly attend this distemper, and for want of knowing these, the farmer has often lost his cattle, not even suspecting the evil.

These symptoms are a dulness in the countenance of the beast, a sluggishness in moving, a heaviness of the eyes, a failure of appetite, an inclination to lay down, an aversion to rise, and, when accompanied with an inflammation of the brain, a giddiness and frequent tossing of the head; besides these the limbs are sometimes affected with stiffness like a rheumatism, and in cows the milk often fails, the udder is hard, and in almost all cases there is a sudden wasting of the flesh.

As soon as the disorder is discovered, an opening into the diseased horn should be immediately made, which may be done

with a twenty-penny-nail gimblet, in a part of the horn which might be ſuppoſed to be moſt favourable for a diſcharge; it is moſt prudent to bore, at firſt, two or three inches above the head; if it is found hollow, and the gimblet paſſes through to the oppoſite ſide without reſiſtance, and no blood diſcharges from the aperture, it may be beſt to bore ſtill lower, and as near the head as it ſhall be judged that the hollowneſs extends. This opening is a neceſſary meaſure, and often gives immediate relief. Care muſt be taken to keep it clear, as it is apt to be clogged by a thin fluid that gradually ouzes out and fills up the paſſage. Some have practiſed ſawing off the horn, but from the beſt obſervations it does not ſucceed better than boring.

In autumn, 1774, on a farm not far from my houſe, I had four cows ſeized with this diſtemper in the ſpace of a fortnight, the firſt, an old cow, was affected with ſtiffneſs in her hind parts, her milk failed, her udder was hard and ſwelled, her eyes heavy, and her fleſh ſuddenly waſted. My tenant requeſted me to view her, upon an apprehenſion that ſhe had met with ſome hurt. At this time the diſorder was not much known among us; fortunately a perſon fell in my way who had ſeen a ſimilar inſtance, and upon relating the caſe, he ſuggeſted that it was the horn diſtemper, and upon examining her horns, one of them was ſound to be cold, and was immediately bored with a gimblet, which paſſed through to the oppoſite ſide without reſiſtance, and no diſcharge followed; finding the horn hollow, I was led to think that the bones below were carious, and immediately made a mixture of rum and honey, with the addition of ſome tincture of myrrh and aloes, and ſyringed the horn; the injected liquor was ſoon diſcharged at her noſe, tinged with blood; this was repeated ſeveral times, daily, and the injected liquor

liquor continued to run off through the noſe for two or three days; at length it ceaſed to paſs that way.—Emollient fomentations were applied to her bag—theſe were the only applications.—The cow in a few days ſhewed ſigns of recovery, but did not regain her fleſh for ſeveral months. A ſecond and third cow were taken ill; the diſorder being early diſcovered, their horns bored and ſyrringed ſeveral times, they ſoon recovered. A fourth cow, about four years old, was obſerved, in the morning, to have the diſorder, her horns were bored and ſyringed, her tail* cut for the purpoſe of bleeding, and from ſuſpicion of defect in it; by nine o'clock ſhe was ſcarce able to ſtand, at noon ſhe was unable to riſe, her head was very hot, her eyes dull, and ſhe groaned as if in great pain; towards night ſhe appeared as if near expiring, her eyes were unmoved at being touched, and the luſtre of them entirely gone, ſome degree of coldneſs, and a univerſal convulſion attended her; under theſe circumſtances, I directed my tenant to take one ounce of powdered muſtard-ſeed, to ſimmer it in a quart of milk, and add thereto one gill of molaſſes, the whole to be given immediately, afterwards to cover her over thick with ſtraw,—this was ſoon done. In this ſtate ſhe was left in the evening; before morning ſhe had eſcaped from her ſtraw, and was feeding in the field. She recovered without any further application.

In the ſpring of 1779, another cow, of four years old, was ſeized; ſhe was obſerved in the morning to refuſe her food, her eyes were heavy, ſhe hung down her head and manifeſted an unhealthy countenance; the diſorder was ſuſpected, her horns examined;

* Neat cattle are ſubject to a diſorder commonly called the tail ſickneſs, which is a waſting of the bony ſubſtance of the tail, and if not cut off or dilated as far as the defect reaches, often proves fatal. It frequently accompanies the horn diſtemper.

amined; one of them felt cold, was bored, found hollow, and ſyringed; through the day ſhe was giddy, toſſing her head backward and forward, frequently groaned as if in great pain, and upon rubbing her forehead ſhewed ſigns of eaſe, her ſtrength was not much diminiſhed, her natural evacuations by ſtool and urine were free; however, ſhe died the next morning; and, according to the information of my tenant, upon opening the body, the *viſcera* were all ſound, no mark of diſorder was ſeen there; but upon opening her head, the brains appeared of an unnatural colour, and, by his account, tending to a mortification.

From the number of cows ſeized with this diſtemper in the ſpace of a fortnight, as before mentioned, a ſuſpicion aroſe that the diſtemper was infectious; time, however, has ſhewn that it is not ſo, at leaſt in any great degree, for it frequently happens, that among many cattle herding together, one of them ſhall have the diſtemper and the other remain in perfect health.

It appears from the firſt recited caſe, that the injected liquor had a free paſſage from the horn to the noſe; yet, previous to the boring of the horn, there was no viſible diſcharge at the noſe of the waſted ſubſtance, or of any other matter, nor has there been in any other inſtance that I have heard of. As there appears no external diſcharge of the waſted bone, it muſt probably lodge in the cavities of the head, and, in proceſs of time, affect the brain; or the matter may be ſubtilized to a great degree, and be drawn into the circulations. It ſeems ſurpriſing that ſo large a portion of bone as that which fills up the horn ſhould be deſtroyed, and the beaſt manifeſt no more complaints than are commonly obſerved; for the whole ſubſtance is generally loſt, before the complaints riſe ſo high as to excite the notice of the farmer. To account for this, may it not be ſuppoſed,

poſed, that the mortification or diſſolution of the pith is attended with a degree of inſenſibility, and that the diſtreſs diſcovered does not exiſt in any great degree until the brain is in ſome meaſure affected, or the matter is abſorbed, and injures the habit in general?

Air-bubbles are continually forming at the orifice, through which the thin fluid ouzes after the horn is bored. This indicates an internal fermentation, and it is not improbable that putrid matter of ſome kind or other may have given riſe to it. The matter may at firſt be formed on the perioſteum, and entering into the interſtices of the bone, may diſſolve the oily ſubſtance, and form a fluid ſo putrid and corroſive as to diſſolve even the bone itſelf; upon this ſuppoſition, the air within becoming putrid and confined by the heat of the parts, will be largely expanded, from whence a great degree of compreſſion upon the ſurrounding parts muſt enſue; its effects at firſt may be ſmall, after a while greater; at firſt producing no great diſtreſs, after a while ſome pain, but not ſufficient to produce ſuch uneaſy ſenſations as to be noticed; but when the bone is entirely waſted and the putrid air much increaſed, and the compreſſion become great, the tender veſſels of the head muſt feel the force of it; the humors alſo may be highly acrimonious, and produce a general irritation. But from that ſenſible relief that an opening into the horn gives the beaſt, it is more than probable that the diſtreſs diſcovered ariſes from compreſſion, rather than from an effect produced on the blood and juices; for, in ſome inſtances, the beaſt is almoſt inſtantly relieved by making an opening into the horn.

The paſſing of liquors from the horn to the noſe, as in the caſe firſt mentioned, may perhaps be conſidered as an objection againſt

againſt the compreſſion ſuppoſed; but it is to be noted, that though there was a communication between the horn and the noſe in this caſe, yet it does not appear that there was any in divers other inſtances, and in this alſo after ſeveral days.

From late obſervations I am led to conclude, that injections are in general unneceſſary; that when the diſtemper is early diſcovered, no more is required than a proper opening into the horn, keeping it ſufficiently clear for the admiſſion of freſh air, the removal of the compreſſion, and the diſcharge of floating matter. But when the diſtemper has communicated its effects to the brain, ſo as to produce a high degree of inflammation, it is much to be doubted whether any method will ſucceed.

II. *Caſe of a remarkably large Tumour, found in the Cavity of the Abdomen.* By JOSHUA FISHER, *F.A.A. and M.S.*

THE ſubject of the following memoir, was a woman of ſtrong habit, rather ſpare than groſs, and of an active diſpoſition. She lived in a married ſtate from early life, but never had a child; was not peculiarly ſubject to any diſorder, except ſome florid cutaneous eruptions, till at about the uſual time of life the *catamenia* ceaſed. Soon after that period ſhe became ſenſible of an unuſual fullneſs in the abdomen, which continued almoſt imperceptibly increaſing, without any diſagreeable ſymptoms, till ſhe was near ſixty years old, about two years before her death. She then complained of a pain in the left hypochondriac region, which became ſenſibly tumefied; the pain and diſtenſion from thence increaſed, and ſpread over the whole abdomen.

I firſt ſaw her between four and five months before her death; I found the abdomen very large and tenſe, eſpecially on the left ſide, which was the moſt painful: the veſſels in her head and arms, were full and turgid, while an inanition had taken place in the lower extremities, with a variety of ſymptoms ariſing from an unequal diſtribution of the circulating fluids and nervous influence. But the immediate cauſe of her principal complaints was an inflammation, which appeared to be ſeated forward of the *rectum*; although ſcarcely any part of the abdomen was exempt from attacks of the moſt excruciating pain at intervals, yet the lower and poſterior parts were principally affected; and while a ſuppuration was forming (which had probably taken place ſeveral times before I ſaw her) the pain darted a little backward and downward, and terminated in the

rectum, by which a quantity of bloody pus was, at length, discharged. Her bowels were generally conſtipated, and when the ſymptoms were the moſt ſevere, the diſcharge of urine was ſmall, and attended with pain.

The principal medicines that I made uſe of, were *hauſt. ſalin. Ol : Ricin* : with *anodynes p.r.n.* In the ſpace of a few weeks, the ſymptoms of inflammation diſappeared, the ſecretions and excretions became free, and by the uſe of the bark and gentle exerciſe, ſhe recovered a conſiderable degree of ſtrength, the ſymptoms ariſing merely from diſtenſion and compreſſion being very tolerable. This truce laſted about two months : a ſudden ſuppreſſion of perſpiration was followed by a return of her complaints with redoubled violence, and ſome paralytic ſymptoms. On the twelfth day of her relapſe, ſhe diſcharged a conſiderable quantity of purulent matter, intermixed with ſome blood and fœces, but without any relief, and ſhe died on the fourteenth. In her laſt ſtruggles, which were very violent, ſhe diſcharged (probably *per vaginam*) a quantity of darkiſh water, reſembling high-colour'd urine, amounting, by eſtimation, to at leaſt two gallons. This diſcharge conſiderably reduced the bulk of the abdomen, eſpecially of the left ſide.

The day after her death, I went about noon, with the Rev. Mr. *Cutler*, of *Ipſwich*, and Dr. *Spafford*, of *Beverly*, to open the body. We expected that it would not be buried till the day following, but to our great diſappointment, found it was to be interred the ſame afternoon : at length, however, we were allowed an hour to examine it.

On opening the abdomen, which now appeared about as large as in the laſt month of pregnancy, a preternatural ſubſtance preſented itſelf, ſituate a little more to the right ſide than to the

the left, and occupying nearly the whole cavity. After ſeparating it from the contiguous parts, to all of which it firmly adhered, its general figure appeared to be that of a cone or pear; the lower part (ſuppoſing the body erect) being within the *pelvis*, was very nearly conical; the upper part was divided by two grooves, running in a right line from its baſis, towards the apex; the one on its anterior, the other on its poſterior ſide, dividing it into two lateral portions, and giving it the appearance of its having been formed by two globular bodies, compreſſed together. The poſterior groove correſponded to the projection of the ſpine, to which it adhered; the anterior groove was wider, and the protuberances on each ſide ſomewhat larger. The baſis lay above the kidneys, and the apex nearly low enough to form a tumour in perinæo: By cutting into it, it appeared to be an uniform ſchirrus of a cineritious colour, with veſſels, or rather perforations interſperſed, for conveying the circulating fluids. From its ſituation, connections and figure, it appeared to have originated in both the *ovaria*; the two ſchirroſities in proceſs of time united, and meeting with the leaſt reſiſtance from below, extended into the *pelvis* 'till the cavity was compleatly filled. It weighed upwards of ten pounds and a quarter, averdepois weight. We made ſome obſervations on the neighbouring viſcera, but for want of time, they were unavoidably very imperfect.

The *veſica urinaria* was moderately diſtended with urine, forming a tumour over the *oſſa pubis*, the neck being compreſſed between the *pubis* and the ſchirrus; its whole anterior ſurface was firmly attached to the *peritoneum*, and the poſterior to the ſchirrus, except a ſmall portion in the middle of it, which adhered to the *uterus*, where that viſcus intervened. The ure-

ters, for the ſpace of two or three inches, ſeemed to lie looſe, and contained a ſmall quantity of urine; their coats were thin and conſiderably diſtended. They then entered upon the ſchirrus, one on each ſide, involved in a membrane hereafter mentioned, running obliquely forward and downward, till they entered the bladder; after they were connected to the ſchirrus, their appearance was the reverſe of the former: to enable them to take this circuit, they had been greatly extended, and their diameters were exceedingly ſmall. The *uterus* was extended in a right line upon the ſchirrus from its baſis, to which the *fundus uteri* adhered, through the anterior groove, almoſt to its apex, continuing about an inch and a quarter wide, and firmly attached through its whole length. Its coats appeared in a natural ſtate, except that they were thinner by reaſon of their extenſion.

The appearance of the *tubæ fallopianæ* was ſo unnatural that they were ſcarcely diſtinguiſhable; we found a membranous covering cloſely embracing the baſis, the anterior, and lateral ſides of the ſchirrus, extending downward nearly to the *pelvis*; and by its upper and lateral edges adhering to the ſchirrus, it ſeemed to ariſe from the *uterus*, which was ſituated in the middle of it, and its external membrane was a continuation of the external membrane of the *uterus*. Through this expanſion on the baſis of the ſchirrus were ſeveral ſmooth but irregular apertures, of about two inches circumference, through which the baſis of the ſchirrus appeared; it was here about a quarter of an inch thick, its fibres fleſhy and variouſly convolved, the lower part of it was much thinner and purely membranous. That part of this tegument which was ſpread upon and near the baſis, appeared to be formed by a diſtenſion of the fallopian tubes included in the

peritoneum

peritoneum or common membrane of the abdomen, and the remainder of it by an expanſion of thoſe duplicatures of the ſame membrane, uſually termed *ligamenta lata.*

On the backſide, the ſchirrus was attached to the *aorta, vena cava,* &c.—to the *rectum,* which was protruded to the right ſide of the ſpine, it adhered for the ſpace of ſeven or eight inches: Near the baſis, the adheſion was ſtrong; but a little lower, the connecting membrane contained a quantity of grumous blood, appeared putrid, and in ſome places was deſtroyed.

We wiſhed to have aſcertained the ſource of the water which the patient diſcharged at the time of her death: by the appearance of the viſcera there had been none diffuſed in the cavity of the abdomen; and, from the circumſtances above mentioned, it muſt have been contained in the left *hypochondrium*: In removing the ſchirrus, we found a membrane (a ſac to appearance) adhering to it, which we cut through, and ſuppoſed to be an empty hydropic cyſt; but the ſchirrus at that inſtant engroſſed our attention; and people ſoon collecting to attend the funeral, all further examination was prevented.

We obſerved nothing extraordinary in any of the other viſcera; the *omentum,* as is uſual in tabid caſes, was nearly waſted, and a number of the meſenteric glands were enlarged and indurated.

III. *Remarks on the Effects of ſtagnant Air.* *By* EBENEZER BEARDSLEY, *Surgeon of the 22d Regiment of the* American *Army, in the Campaign of* 1776.

ABOUT the beginning of April, 1776, the *American* army, under the command of his Excellency General *Waſhington*, marched from *Boſton* for *New-York*, at which place they arrived near the middle of the month. The ſick and invalids having been left behind, the whole army were in perfect health. They took up their quarters in the barracks and houſes of the citizens, 'till about the firſt of May, when they all went into tents, except the 22d regiment, under the command of Colonel *Samuel Wyllys*, who, for want of tents, continued in their quarters in *Smith-Street*. This regiment was very healthy until about the middle of the month, when upwards of one hundred of the men were taken down with the dyſentery in the ſpace of one week. Such a ſudden invaſion of this formidable diſeaſe alarmed me greatly. As I found upon enquiry that there was not a ſingle dyſenteric patient beſides, in the whole army, I concluded that the diſeaſe aroſe from ſome cauſe peculiar to the city: but after a careful enquiry, I could not find that there was a ſingle inhabitant in the whole city that was ſick with the diſtemper. Thoſe who lived in the ſame ſtreet, and many of them in the ſame houſes with us, were entirely free from this, or indeed any other diſeaſe. For ſeveral days I was much perplexed, and greatly at a loſs as to the cauſe. At length I obſerved that not only the citizens with whom we lived were free from the diſeaſe, but that ſome whole companies of the ſame regiment had nothing of it. This led me to conſider more minutely the ſituation and circumſtances of thoſe who were ſick; all of whom, I found, lived either in low

low underground rooms, or else in garrets, so situated as not to admit of a free circulation of air. The rooms were also considerably less in proportion to the number of men than usual. Struck with these discoveries, I concluded at once, that the disease arose from a confined stagnant air; deprived by this means of its natural elasticity, and loaded with putrid *effluvia* from the bodies of the unhappy people who lived in it. Having communicated my discoveries to the Colonel, I requested that the men, (both sick and well) might be removed out of those rooms into such as were more airy and capacious. This measure was attended with the most salutary consequences. Those who were sick recovered in a short time, except one or two that died; and no more being seized with the disease, in a few weeks the regiment became entirely healthy. There was nothing peculiar in the symptoms which attended the disease, except, as is usual in vernal distempers, that there was a greater degree of inflamation than commonly attends autumnal disorders of the same *genus*. The discovery of this singular instance of the pernicious effects of confined stagnant air, was of great use to me in the course of the campaign. In the months of July and August, the dysentery, bilious and other fevers of the putrid kind, became very rife both in the army and country. Great pains were taken to procure for our men who were sick with any of those disorders, large rooms, and to have them well ventilated. Yet, under these circumstances, I frequently observed, that (ceteris paribus) the sick who lay in and near the corners of the rooms, were handled much more severely than those which lay in the middle of them.

I do not remember to have met with this observation before, but it is undoubtedly of great importance in the treatment of dysenteries and other putrid diseases.

IV. *A remarkable Case of Gun Shot Wound. Communicatd in a Letter from* BARNABAS BINNEY, *Hospital Physician, and Surgeon in the* American *Army, in* 1782, *to the Honorable* BENJAMIN LINCOLN, *Esq;* F. *A. A.*

ON April 9, 1782, *David Beveridge*, a seaman, belonging to the sloop of war General *Monk*, was brought into the military hospital at this place, having been wounded the day before. He was a lad of about nineteen years of age, and in a good state of health, at the time of the action between the said ship and the *Hyder-Ally*. In that action he was in the main-top of the *Monk*, when he received a musket-ball in his belly from one of the marines on the quarter-deck of the *Hyder-Ally*, then within fifteen yards of the *Monk*. The ball entered his belly about two inches above his left groin, and within an inch of the anterior edge of the left *ilium*, passing out two inches on the right of the spine between the two inferior true ribs, just touching the cartilage of the inferior angle of the right *scapula*. When he came into the hospital he had bled much, was very weak and cold, had a faultring voice, a cadaverous countenance, and a constant hiccup, while his fœces passed freely out of the wound in his belly. In this deplorable condition, where neither art nor nature could promise any permanent relief, the only dictate of humanity was to smooth the path of death. Being also in great pain, I advised him to take a glass of *Madeira* wine, with twenty or thirty drops of *liquid. laudan.* in it, as often as necessary. He accordingly began, and continued this practice 'till the thirteenth, finding constant relief from it. He took no kind of sustenance all this time excepting wine whey, never having any kind of discharge *ab ano* from the moment he was wounded, but constantly squirting with considerable force what

what fœces he had, through the wound in his belly. On the fourteenth he had a common glyſter adminiſtered, the greateſt part of which alſo came out at the wound, the remainder coming as it went, *ab ano*, without bringing any fœces. From the fourteenth to the eighteenth he took conſiderable quantities of gruel and whey, with a little wine occaſionally, having no inteſtinal diſcharge whatever but what was made through the wound in his belly. On the eighteenth, as his ſtrength was much increaſed, and as the wounds were conſiderably contracted, and looked well, I ordered another injection to be adminiſtered gently, when, for the firſt time, in eleven days he had a natural ſtool. From this time he had no further diſcharge of fœces through his wound; his excretions became as regular and as natural as ever they were; his wounds ſuppurated and healed kindly; his ſtrength returned; and he was exchanged nearly as well as ever, on the thirtieth.

That the ball had paſſed through the colon is obvious, from the diſcharge of perfect fœces and of the injection adminiſtered, *ab ano*. That his life depended upon our not meddling with the wound, and upon keeping him quiet and eaſy, is alſo plain; as the leaſt removal of the orifice in the inteſtine from the orifice through the abdomen, which were ſo happily oppoſed to each other, muſt have been attended with a fatal diſcharge of the fœces into the abdomen. That the diaphragm and lungs were perforated is plain, from the courſe of the ball, and his profuſe hæmoptoe. That Surgeons may be too officious, as well as too tardy; and that where they are not certain of the utility of their operations, they had better leave even the moſt deſperate diſorders to the management of nature, ever provident, and generally adequate, are points remarkably enforced in this particular caſe.

V. *A Bill of Mortality for the Town of* Salem, *for the Year* 1782. *By* EDWARD AUGUSTUS HOLYOKE, *M. D. F. A. A. and M. S. In a Letter to Mr.* CALEB GANNETT, *Rec. Sec. A. A.*

S I R,

I Herewith fend you a bill of mortality, for the town of *Salem*, for the laft year, which, although not fo accurate as I could wifh, may yet perhaps be worth communicating to the Academy; heartily wifhing the public might be favoured with more correct bills of a like kind, from a variety of towns, of fimilar,and of different fituations, for a courfe of years fucceffively, as they would certainly afford the beft means of judging of the ftate of population, a matter of real ufe and of great curiofity.

Salem is a fea-port town, fituated in the 42d degree of N. Lat. on *Maffachufetts-Bay*, about five leagues to the weftward of *Cape-Ann*, and about as far north-eaftward from *Bofton*; where a confiderable trade is carried on both with *Europe* and the *Weft-Indies*. That part of it which is fettled thickeft, is moftly a peninfula lying between two falt water rivers. The ground is flat and low, being fcarcely more than twenty, or twenty-four feet above the level of the fea, at high water, any where, and in moft places not near fo much; and excepting a hill in the north-weft, and another to the weftward, neither of them very high, there are no eminences to interrupt the free courfe of the winds. The foil is in general light, dry and fandy, and quite free from any marfhes or collections of ftagnant waters. The water of the wells, which are very numerous, is pretty good, that of many fo pure as to bear foap well; though, I think, our tea-kettles are generally covered on the infide with a ftony cruft.

The

The inhabitants are not ſubject to any endemic diſorders; though, thirty or forty years ago, hyſteric and nervous complaints, are reputed to have been more than commonly riſe here; at preſent, I believe we are as exempt from ſuch maladies as the neighbouring towns.

In the following bill the number of the *dead*, I believe, is pretty accurate; the *ages* of the deceaſed in general, and the *month* they died in, are tolerably aſcertained; but as to the liſt of *diſeaſes*, I cannot be anſwerable for a conſiderable part of it, as the beſt account I could procure of the diſeaſe is ſometimes taken from the ſextons, the reports of nurſes or perſons about the ſick; and how uncertain *that* muſt be, I need not ſay, when even phyſicians themſelves are often at a loſs how to claſs the diſeaſes of their patients, with the preciſion they would wiſh; and in ſeveral inſtances I have not been able to procure any account of the diſeaſe at all: I thought it better, however, to give a bill of that ſort, imperfect as it is, than to ſuppreſs it entirely. As to the *births*, I believe the account is as compleat as can be expected, conſidering from whom we are obliged to collect the greateſt part of it; and, I ſuppoſe, approaches much nearer to the number of perſons actually born, than accounts of chriſtenings ever can, in any country where there is a general religious toleration; indeed, in a town where there are various religious ſects, ſome of which never adminiſter baptiſm at all, and others who never adminiſter it but to adults, which is our caſe, births can never be tolerably gueſſed at from an account of chriſtenings. Theſe however are not neglected, the gentlemen of the clergy having been ſo obliging as to furniſh me with a compleat liſt of their ſeveral baptiſms; from the ſame hands too, and from the Juſtices of the Peace, who by our laws are quali-

fied to marry, I am favoured with the number of couples married. The number of rateable polls, &c. I have from the assessor's list. I would further observe, that the year 1782, taking it throughout, was more sickly than ordinary, and I have great reason to think that we have not had so great a mortality, since the year 1773, which is the more remarkable, as no epidemic disorder has been uncommonly prevalent.

I should have been glad to have procured a more particular bill, as well as a more accurate one, but found it impracticable.

I am &c.

E. A. HOLYOKE.

Mr. CALEB GANNETT.

A Bill of Mortality for *Salem*, for the Year M,DCC,LXXXII.

GENERAL BILL.

Deaths	175
Births	317
Baptisms	152
Marriages	70
Rateable polls, *i.e.* males, from 16 years old and upwards, resident in the town,	897
Transient persons—males,	200

MONTHLY BILL.

January, died	21
February	11
March	9
April	12
May	8
June	11
July	11
August	12
September	35
October	22
November	10
December	13
	175

BILL OF AGES.

Still-born	6
Within the month	6
Between 1 mon. and 1 year	30
1 year and 2	20
2 and 5	2
5 and 10	7
10 and 15	3
15 and 20	6
20 and 25	5
25 and 30	7
30 and 40	24
40 and 50	10
50 and 60	7
60 and 70	2
70 and 80	7
80 and 90	6
Ages unknown, of children chiefly,	27
	175

BILL

Bill of Diseases.			
		Putrid	1
		Nervous	2
Angina	3	Rheumatic	1
Aphthæ	2	Hydrocephalus Internus	4
Apoplexy	2	Hypochondriacism	1
Ascites	3	Lethargy	2
Asthma	1	Lientery	1
Atrophy	5	Old Age	7
Cachexy	7	Over-Eating	1
Chin-Cough, combined with Dysentery and Cholera Dysenterica	7	Paralytic	6
		Phthisis Pulmonalis	13
		Ricketts	2
Cholera Morbus	1	Ulcers sinuous	1
Cholera Dysenterica	20	Vomiting	1
Coeliaca	1	Worms	1
Complicated Case	1	Suddenly	5
Consumption	4	New-born	6
Convulsion	7	Still-born	6
Diarrhœa	3	Casualties 7, viz.	
Dysentery	6	Burnt	3
Empyema	1	Drowned	1
Erysipelas	1	Frozen	1
Fevers	8	Over-laid	1
Catarrhal	4	Scalded	1
Hospital	3	Diseases unknown of	13
Pleuritic	2		
Peripneumonic	3		175

A Bill of Mortality for *Salem*, for the Year M,DCC,LXXXIII.

General Bill.		Monthly Bill.	
Deaths	189	January	5
Births, about	385	February	9
Baptisms { Boys 80, Girls 78 }	158	March	9
		April	11
Marriages, about	84	May } Measles were epidemic {	33
		June	24
Rateable polls, *i. e.* males, from 16 years old and upwards	1000	July	14
		August	17
Number of inhabitants estimated at about	9000	September	25
		October	12

November	14
December	16
	189

BILL OF AGES.

Still-born	14
Within the month	11
Between 1 mon. and 1 year	27
1 year and 2	29
2 and 5	28
5 and 10	12
10 and 15	3
15 and 20	2
20 and 25	8
25 and 30	8
30 and 40	9
40 and 50	8
50 and 60	7
60 and 70	6
70 and 80	6
80 and 90	2
Ages unknown of	9
	189

BILL OF DISEASES.

Anasarca after Scarlet Fever	4
Angina	1
Apoplexy	3
Ascites	1
Asthma	2
Atrophy	4
Cachexy	2
Cancer	1
Child-birth	1
Cholera Dysenterica	8
Coeliaca	3
Complication	3
Consumption	5
Convulsions	8
Cynanche-maligna	5
Dysentery	6
Epilepsy	4
Empyema	1
Fevers	
From dentition	1
Pleuritic	1
Peripneumonic	5
Rheumatic	2
Scarlet	2
Synochus	5
From worms	1
Hard-Drinking	1
Hæmoptosis	1
Head mould-shot	1
Hydrocephalus Internus	1
Inflamed Intestines	1
Imperforate Anus	1
Lientery	1
Lock'd-Jaw	1
Measles	16
After Measles, of Angina	2
Fever	3
Consumption	2
Dysentery	2
Peripneumony	7
Sphacelus	1
Synochus	1
Old Age	5
Oppression	1
Paralytic	1
Phthisis Pulmonalis	13
Scrophulous Ulcers	2
Suppressio Urinæ	1
Spasm at Stomach	1
Vomica	1
Vomiting	2
Worms	3
New-born, *i. e.* within the month	11
Still-born	14
Suddenly	2
Shot dead	1
Diseases unknown of	10
	189

VI. *A History of a large Tumour, in the Region of the Abdomen, containing Hair.* *By* JOHN WARREN, *Esq;* *F. A. A.* *and M. S. and Professor of Anatomy and Surgery in the University of* Cambridge.

AN aversion to the making of large incisions, into such tumours as have appeared to have been seated within the cavity of the abdomen, has perhaps often been the reason, why those of them, which have happened to contain a substance less fluid than pus, have either induced a hectic, from a copious absorption of the thinner and more acrid parts; or, have speedily been followed by a fatal termination. The following history, may in some measure evince the safety of such large and free openings, in cases of this kind; but the facts contained in it, may also admit of an application to the purpose of explaining certain *phenemena* in the *animal œconomy*.

The production of hair in the human body, though it has often been the subject of accurate examination, and ingenious speculation, has perhaps never yet been satisfactorily accounted for; or to say the least, the solution is still destitute of that support and conviction, which in most other physiological inquiries, have so happily been attained.

Admitting the position, that many, if not all the interior parts of the body, are furnished with the necessary fluids for the growth of this substance, an accurate attention to the circumstances under which it is really produced, and to the nature of the parts in which it is most frequently found, must undoubtedly afford very considerable light on the subject; and from a large number of such facts, carefully and judiciously collected, it

it is not improbable that every doubt and difficulty, attending the inveſtigation, may be entirely removed.

Z—— H——, a negro woman, about thirty-two years of age, early in the year 1783, applied for medical aſſiſtance, in a caſe of a ſwelling in the abdomen, which had become extremely painful, and which began to be attended with very threatening ſymptoms. On examination, a very large tumour was found ſeated chiefly on the left ſide, occupying the whole ſpace between the left *os ilium* and the left inferior ribs, and extending over to the right of the *umbilical region*, pointing a little to the left ſide of the navel, conſiderably hard, and extremely ſenſible. Upon inquiry into the origin of the tumour, it appeared, that the patient had firſt complained of pain in the left groin, and a general enlargement of the abdomen, immediately after delivery of her third child: This gradually increaſed after two ſucceſſive labours, and ſince the birth of her laſt child, now about twelve years of age, had been almoſt conſtantly painful, though by no means in a very diſtreſſing degree, until about three weeks prior to her application for advice. At this period her complaints were greatly exaſperated, in conſequence of catching cold at the time of the catamenial evacuation, by which a total ſuppreſſion was induced. The common diſcutient topical applications were immediately made uſe of; the uſual methods were employed to renew the diſcharge; but all to no purpoſe. The ſwelling conſtantly increaſed for about three weeks, when an evident tendency to ſuppuration being perceived, the method of cure was immediately altered from a diſcutient to a ſuppurative proceſs. In about two weeks, a fluctuation was perceptible, and at the end of two more, an opening into the cavity of the tumour was determined upon.

An

An extensive incision was accordingly made through the *rectus* muscle, at a sufficient distance from the usual course of the *epigastric* artery to avoid all danger of wounding it, and about a pint of watery matter immediately issued through the orifice ; after which about the same quantity of pure pus was discharged.

On introducing two or three fingers into the cavity, a quantity of soft substance was felt within it, much about the consistency of soft soap. I immediately made use of a table-spoon, as the most convenient instrument that could be readily procured for extracting it, and about a pound of it was at this time obtained ; after which, as a degree of faintness began to ensue, the wound was dressed, and the patient placed in her bed, in a proper situation for admitting of a free discharge of any fluid that might still be retained.

At the three or four succeeding dressings, a portion of the same substance was taken out, till the whole being extracted, it amounted to the quantity of about four pounds.

At each dressing, the matter was particularly examined, and was found to contain a large quantity of short hair or wool, about three quarters of an inch long, uniformly mixed with it, as is seen in the specimen herewith presented for the inspection of the Academy.

In each hair was discoverable by the naked eye, a bulbous root, and a pointed extremity, both perfectly similar to what is seen in an intire hair produced naturally in other parts of the body. After the removal of the whole substance, the hand was passed into and round the cavity in search of bone, or any other foreign body which might be contained within it ; but though some of the gentlemen present, on supposition of an *extra-uterine fœtus*, expected to have found the former, yet nothing of

either could be felt, though every part was fairly acceſſible. From this examination, it evidently appeared, that the matter extracted had been contained in a ſac which firmly adhered to the *peritonæum*, a circumſtance, I believe, generally attendant on ſuppurations in the viſcera of the abdomen, as the natural conſequence of previous inflammation.

On being expoſed to the heat of the fire in an open veſſel, it emitted a ſtrong urinous ſmell, and was attended in other reſpects with moſt of the appearances uſually exhibited in the broiling of animal ſubſtances. The action of flame produced a ſmart and continued decrepitation of the ſalt contained in it, until the whole was reduced to a ſimple coal; but no ſigns of inflammability, or the preſence of any oily ſubſtance, were perceptible. When boiled, the water made uſe of in the proceſs was very little changed as to its ſenſible properties; but after ſtanding ſome time in a veſſel to cool, it depoſited a ſediment which was ſuſpected to be an alkaline ſalt, and which accordingly readily fermented with the vitriolic acid.

The patient, from the uſe of the bark, ſuperficial dreſſings, and a reſtorative diet, was, in about three months, enabled to enter upon her uſual employment, which was buſineſs of the moſt laborious kind. She had during her illneſs been much reduced, and for ſome time continued in an emaciated ſtate, yet ſhe now enjoys perfect health, and has become moderately corpulent. The catamenial evacuation has been regularly performed; but no ſigns of pregnancy have ever appeared, though before her ſickneſs, ſhe had borne children uncommonly faſt.

Many of the practitioners in the town of *Boſton* were called in to viſit the patient, and various were the conjectures upon the

nature

nature of the caſe. The abſence of all the uſual ſigns of pregnancy, except at thoſe periods which regularly preceded the reſpective deliveries abovementioned, is a ſtrong argument againſt the hypotheſis of an *extra-uterine fœtus*; and it ſhould ſeem by no means admiſſible, that the bones ſhould have been ſo perfectly diſſolved as to have formed with the muſcular, and other ſoft parts of a fœtus, one uniform and apparently homogeneous maſs of matter. Are we not authorized, from the general complexion of the caſe, particularly from the pain in the groin of the affected ſide, to pronounce the *ovarium* to have been the ſuffering part? The attachment of the *ligamentum rotundum* of the *uterus* to the adipoſe ſubſtance in the groin, ſeems to point out, either the *uterus*, or ſome other part connected with it, as the ſeat of the diſorder.

A diſeaſed *ovarium* may eaſily be conceived to acquire a ſize too great to admit of it's being contained in the *pelvis*, and from its elevation in the abdominal region, the *uterus* itſelf might alſo be raiſed, and a diſtention of the ligament thereby be produced. But it is farther probable, that from an immediate adheſion of the *ovarium* to the neighbouring part of the *uterus*, the inflammation with which thoſe parts might be affected, would extend to the ligament itſelf; the former cauſe operating in conjunction with this, would ſufficiently account for the pain in the groin of the affected ſide; and the application of this reaſoning in the above inſtance, together with the other facts contained in the hiſtory, might enable us, without much difficulty, to form a pretty ſure diagnoſis of the diſeaſe.

VII. *Experiments on the Waters of* Boſton. *By* J. FERON. *Surgeon-Major of his Moſt Chriſtian Majeſty's Squadron, under M. de* TERNAY'S *Command in* North-America, *and of his Majeſty's Marine Hoſpitals at* Boſton *and in* Rhode-Iſland, *F. M. S.*

WATER, a tranſparent, colourleſs, inſipid body, commonly fluid, being part of the elementary compoſition of all bodies, excepting metals, and ſo eſſential to the exiſtence and preſervation of thoſe into whoſe compoſition it enters, ought to be an object of careful attention.

That water which is a part of the elementary compoſition of bodies is pure; if it was equally pure in the different repoſitories where we find it, it would need no analyſis, it would every where produce the ſame invariable effects, for the purpoſes of animal and vegetable life, as well as in the various uſes to which it is daily applied; but as it is capable of diſſolving many other ſubſtances, and of retaining them diſſolved or ſuſpended, we ſeldom find it pure; it is always, more or leſs, loaded with foreign materials. Theſe

Eſſais ſur la Nature des Eaux de Boſton. *Par* J. FERON, *Chirurgien-Major de les Cadre de ſa Majeſté tres Chretienne, ſous les Ordres de M. de* TERNAY *dans le Nord de l'*Amerique, *et de l'Hôpital de Marine de ſa Majeſté a* Boſton *et a* Rhode-Iſland, *M. S. M.*

L'EAU ce corps diaphane, inſipide, ſans couleur, ordinairement flùide, élèment de tous les corps, exceptés les metaux, ſi éſſentiel à l'exiſtance et a la conſervation, des êtres dont il fait partie, doit être un object digne de la plus grande attention.

L'eau qui entre comme élèment dans la compoſition des corps eſt pûre, ſi elle etoit telle dans les differens endroits où elle ſe rencontre, elle n'auroit pas beſoin d'analiſe, elle produiroit partout un effet conſtant, ſoit pour l'ûſage animal ou végétal, ſoit pour les differens ûſages auxquels on l'employe journéllement, mais comme ce flùide eſt ſuſceptible de diſſoudre diverſes ſubſtances, et de les tenir diſſoutes ou ſuſpendues, on le trouve rârement pûr, il eſt toujours plus ou moins chargé de matieres étrangeres. Ces matieres different en raiſon des endroits par oû l'eau paſſe ou ſejourne,

Theſe materials differ according to the places through which the water paſſes, or in which it is collected, in ſuch manner that it may be impregnated with one or many foreign principles which change its qualities, and render it in general prejudicial to health, and unfit for artificial uſes, though, indeed, in ſome caſes, they are favourable to both. Thus every one knows the efficacy of certain mineral waters in diſeaſes, and the utility of the waters of certain rivers and lakes for the uſe of dyers; for inſtance, the advantage of mixing the waters of the *Rhone* and *Saone*, at *Lion*, for dying black, the water of the *Saone* alone for crimſon, deep ſcarlet, cherry colour and violet, while thoſe of the *Rhone* alone are prefered for white, green, grey, yellow, &c. the river of *Gobelins*, at *Paris*, for ſcarlet, and others for different colours. Many of theſe diſcoveries are the reſult of accident; for others we are indebted to analytical inveſtigation. The analyſis of water then, is an object of importance, both to medicine and the mechanic arts.

I

ſejourne, deſorte qu'elle peut être chargée d'une ou pluſieures ſubſtances étrangeres a ſa nature, qui âlterent ſes qualités, et la rendent en général préjudiciable a la ſanté et aux arts quoique dans certains cas elles les favoriſent; en effet perſonne n'ignore les bons éffets de certaines eaux mineralles dans pluſieurs maladies, et de l'utilite qu'on tire, de celles de quelques lacs ou rivieres, pour les teintures, tel qúa Lion, les eaux du Rhône melées avee celles de la Saône pour le noir, l'eau de la Saône ſeule pour le cramoiſi, le ponçeau, le çeriſe, le violet, & les eaux du Rhône ſeul ſont préferrées, pour le blanc, le vert, le gris, le jaune, &c. la riviere des Gobelins a Paris pour la couleur écarlate, ainſi que d'autres pour differentes couleurs; pluſieurs de ces connoiſſances ſont dûes au hazard, mais on eſt rédevable dún grand nombre aux analiſes. L'analiſe des eaux ſemble donc etre un object qui merite l'attention du medicin et de l'artiſte.

Je ne promets pas de rémplir la tâche que préſénte un travail auſſi grand; j'expoſerai ſeulement les diverſes éxperiences que j'ai fait, et leur réſultats, avec autant de circonſpection

I do not engage to enter at large into a work ſo extenſive, I ſhall only relate the experiments I have made, and the reſult of them, with the neceſſary preciſion; and on the iſſue of theſe experiments, I ſhall form a determination of the qualities of the waters of *Boſton*.

Sea water does not every where furniſh the ſame reſiduum on evaporation. At *Boſton* the reſult was as follows:

A pint* of water taken up at the head of *Long-Wharf*, left upon evaporation 6 drachms† 40 grains; this reſiduum being diſſolved in diſtilled water and filtered, left 6 grains of calcareous earth on the filtre; the filtrated ſolution being evaporated, left 5 drachms 2 ſcruples of ſea ſalt, with an alkaline baſis; from 40 to 47 grains of ſea ſalt, with the terrene baſis, or *ſal. cathart. amar.* and a ſmall quantity of oil.

Pump water being in general uſe, particularly engaged my attention; it is more or leſs charged with heterogeneous parts in proportion

* *The pint was equal to an Engliſh quart.*

† *The Drachm mentioned contains 72 grains.*

circonſpection que la nature du travail exige, ces réſultats me ſerviront de guide pour former un jugement ſur la nature des eaux de *Boſton*.

Les eaux de la mer ne fourniſſant pas partout le même réſidu par l'évaporation, je vais mentionner ce qu'elles mo'nt donné à *Boſton*.

Une pinte * d'eau priſe à la tête du *Long-Wharf*, m'a fourni apres l'évaporation ſix gros † et quarante grains de reſidu, les quels ayant été diſſous dans l'eau diſtilleé a laiſſé ſur le filtre ſix grains de terre calcaire, l'eau évaporée a rendue cinq gros deux ſcrupules de ſel marin á bâſe d'alkali, quarante á quarante ſept grains de ſel marin a bâſe terreuſe ou cathartique amer, et une petite quantité d'huile.

L'eau de pompe étant celle dont on fait un ûſage plus frequent, à fixé plus particulièrement mon attention; elle eſt plus ou moins chargée de parties hétérogênes conformement á ſa proximité avec la mer; ainſi celle des endroits bas eſt moins pûre que

* *Une pinte déau egalle au quart de* Boſton.

† *Le gros de ſoixante douze grains.*

proportion to its proximity to the waters of the ocean. That in low ſituations, is leſs pure than the water in more elevated grounds; it generally contains the ſame principles, except ſuch as have a ſuperabundance of calcareous earth. Among ſuch as I examined, the water of *Beacon-hill, Charter-Street*, and ſome in *New-Boſton*, appeared moſt free from impurities. The weight was generally from 15 to 40 grains above that of diſtilled water; the thermometer ſtanding in the open air at 32°, roſe to 40 and 46 on being immerſed, thoſe which contained the moſt impurities being warmeſt. Theſe waters have a brackiſh taſte to ſtrangers, and the inhabitants themſelves are ſenſible of it on drinking the purer element, which ſeems ſoft and inſipid; they are hard and do not diſſolve ſoap. I began with determining by the alkaline lixivium uſed in making Pruſſian blue, whether they contained any metallic principle; and being ſatisfied that they did not, I made the following experiments: I put into two ſeparate vials, equal parts of diſtilled water and of pump water, and having added to each an equal quantity of pulverized rhubarb,

que celle des lieux élevés, elle contient généralement partout les mêmes principes, éxcèptés quelques unes qui ſont ſur-chargées d'une quantité de terre calcaire; parmi celles que j'ai analiſées celle de *Beacon-Hill, Charter-Street*, et quelque une de *New-Boſton* m'ont paru les moins impûres. Leur poids eſt depuis quinze jus qu'à quarante grains par pinte plus péſante que l'eau diſtilleé, le thérmometre etant à l'air libre à trente deux, a monté à quarante et quarante cinq, par immerſion; celles qui contenoient le plus de parties hétérogênes etoient les plus chaûdes.

Ces eaux ont un gout unpeu ſaûmatre pour les etrangers, dont les habitans de *Boſton* ſ'apperçoivent quand ils en boivent de plus pûre la quelle ils trouvent fade et trop douce. Elles ſont dûres au toucher et ne diſſolvent pas le ſavon.

Je commencais d'abord par m'aſſurer au moyen de la leſſive alkaline pour le bleu de Pruſſe, de l'exiſtance ou non-éxiſtance d'une ſubſtance metallique quelconque & perſuadé qu'il ny en avoit pas, je fis les expériénces ſuivantes.

Je

rhubarb, I expofed them to the fame degree of heat. The diftilled water gave a fine yellow tincture, but in the other it was a deep yellow, inclining to red. The fame experiment was made with cochineal, the one yielding a fine red, the other a deeper colour, verging to crimfon, afterwards the colouring particles were precipitated, partly or intirely, according to the quantity of water. Logwood, inftead of a lively, gave only a dull red, inclining to crimfon; and with beet-juice the refult was the fame. Nutgalls gave out a tinge of their own colour in pure water, it was darker and more opaque in pump water, and a fmall addition of the fixed alkali turned it to a deep green.

Thefe experiments feem already to indicate the nature of a falt with an earthy bafis, having fome marks of the marine acid. I poured upon a quantity of water, a folution of filver in the nitrous acid; there was immediately formed a white cloud, which foon after became pearl coloured, and then of a darkgrey; a folution of mercury, in the fame menftruum, produced a cloud and white

Je mis feparement dans de deux bouteilles, parties égales de l'eau diftillée et de l'eau de pompe, j'ajoutai dans chaque le meme poids de rhubarbe en poudre, et les expofai au même degré de chaleur; l'eau diftilleé a donné une teinture d'un beau jaune, tandis que l'autre a produit un jaune foncé tirant fur le rouge.

La même experience a été faite avec la cochenille, l'une a fourni un beau rouge, et l'autre a donné d'abord un rouge foncé qui auffitôt paffa au cramoifi, enfuite la partie colorante a été precipiteé en grande partie, ou entiérement, felon la qualité de l'eau; le bois de campêche au lieu de fournir une teinture d'un beau rouge, a donné un rouge foncé et cramoifi. Le fuc de bette rouge a produit le même éffet. La noix de galle a fourni une teinture de fa couleur dans l'eau pûre, elle a été plus foncé et opâque avec l'eau de pompe, et bien peu d'alkali fixe la rendoit d'un vert foncé.

Ces experiences femblent déja indiquer la nature d'un fel à bâfe terreufe, donnant quelques indices d'acide marin.

Je

white precipitate : a ſolution of the fixed alkali, or the alkali fluor, produced a white cloud, and the precipitate was about ſix grains to a pint ; it diſſolved in acids with effervеſcence. Some of theſe waters (that of the cold bath in *Water-Street* for inſtance) being put into bottles, a quantity of air was perceived riſing in bubbles to the ſurface, and, by reſt, was entirely diſſipated, and then there might be diſcovered a ſmall ſediment. Lime-water dropped into theſe waters, formed a white cloud, and detached a precipitate of the ſame colour.

The water of *Beacon-hill*, and *Charter-Street*, gave no ſuch precipitate with the alkalies nor with lime-water.

Does not the precipitation formed by the lime-water, joined to the air-bubbles, and the ſediment taking place on their eſcape, indicate an earth ſuſpended by means of a ſuperabundance of air ?

I proceeded next to evaporation ; a pint gave from 10 to 36 grains of a ſaline earthy reſiduum, of a yellowiſh colour, which

 left

Je verſai ſur une quantité d'eau, quelques goûtes de diſſolution d'argent par l'acide nitreux, il ſe forma ſur le champ un nûage blanc qui bientot apres devint couleur de perle, et enſuite gris foncé ; la diſſolution de mercure par le même acide donnoit un nûage et precipité blanc ; une diſſolution d'alkali ſixe, ou l'alkali fluor faiſoit paroitre un nûage blanc et le précipité etoit d'environ ſix grains par pinte, il ſe diſſolvoit dans les acides avec éffervеſcence ; quelques unes des eaux tel que celle de *Water-Street* ; * par exemple, miſes dans des bouteilles laiſſoient apperçevoir une grande quantité de bulles d'air qui montoient à la ſurface et ſe diſſipoient par le repôs ; on apperçevoit alors un peu de ſediment, l'eau de chaux verſée goûte a goûte dans ces eaux, formoit un nuage blanc, et laiſſoit dépôser un precipité de la même couleur ; les eaux de *Beacon-Hill* et de *Charter-Street* ci devant mentionnées, ne flourniſſoient point ce precipité avec les alkali, ni avec l'eau de chaux.

Le precipité que forme l'eau de chaux joint aux bulles d'air que l'on apperçoit et au ſediment qui ſuit leur evaſion, ne ſemblent ils pas demontrer une terre ſuſpendue au moyen dune ſur abondance d'air ? Je

* *Cold Bath.*

left on the tongue a ſaltiſh diſagreeable taſte; thrown on a red-hot iron in the fire, there was no decrepitation; expoſed to the air, it ſwelled and grew white, attracting a little moiſture.

A drachm and 12 grains of this reſiduum diſſolved in diſtilled water, left on the filter 19 grains of a greyiſh earth, which was in part ſoluble in the nitrous and marine acids, but leſs ſo in the vitriolic, it was precipitated from the two former by the laſt. Having evaporated the liquor to a pellicle, it gave no regular cryſtals by cooling nor evaporation; a ſaline pellicle was formed on the liquor, which I broke to forward the cryſtallization of what remained; this was of a yellowiſh colour, and compleatly exſiccated with great difficulty. This ſaline ſubſtance was neither acid nor alkaline, it left a ſaltiſh impreſſion on the tongue, and a copperiſh taſte, decrepitated a little on the coals, and diſſolved eaſily in water. Fixed or volatile alkali added to this ſolution, cauſed no ſudden change, but a precipitation enſued ſoon after. Pouring upon this ſalt, the marine or nitrous acids,

Je procedai enſuite à l'evaporation, une pinte m'a fourni depuis dix juſqu'a trenté ſix grains de réſidu ſalin terreux de couleur jaunatre, qui laiſſoit ſur la langue une impreſſion ſaleé déſagreeable, jetté ſur un fer rougi au feu, ne décrepitoit pas, ſ'enfloit et blanchiſſoit, expoſé à lair il attiroit un peu l'humidité.

'Un gros et douze grains de ce réſidu, diſſous dans l'eau diſtilleé a laiſſé ſur le ſiltre dix-neuf grains de terre griſâtre, laquelle etoit en partie ſolùble dans les acides nitreux et marin, et le paroiſſoit moins dans le vitriolique, elle etoit cépendant précipité des deux premiers par le dernier.

Ayant evaporé la liqueur juſqú à pellicule elle n'a point donnée de criſtaux réguliers par le réfroidiſſement, ni l'evaporation, une pellicule ſaline aſſez epaiſſe ſ'eſt formé ſur la liqueur que j'ai rompu pour permettre la criſtalliſation du reſte, qui ne ſ'eſt faite que par deſéchement et de couleur jaunâtre, difficile à ſecher, cette ſubſtance ſaline n'etoit ni acide ni alkaline, elle laiſſoit une impreſſion ſalée ſur la langue et un eſpece de goût cùivreux, décrépitoit unpeu ſur les charbons,

ſe

acids, no motion was excited; but the vitriolic raiſed a conſiderable fermentation, with vapours like thoſe where this acid is poured on dried ſea ſalt. This ſalt, expoſed to the air, attracted moiſture; but not ſo readily as that of which we ſhall preſently treat.

From theſe various experiments, may we not conclude that the waters of *Boſton* contain a ſea ſalt with a baſis of mineral alkali in ſmall quantity, a greater quantity of ſea ſalt with an earthy baſis, a certain quantity of oil, perhaps a little of *ſal catharticus amarus*.

There are beſides ſome which contain farther a ſuperabundance of earth, ſuſpended by means of an undue proportion of air.

To arrive at greater certainty, and make my experiments more deciſive, I combined ſea ſalt with an earthy baſis, by mixing powder of coral with the marine acid; the cryſtallization was

 like

ſe diſſolvoit aiſement dans l'eau; l'alkali fixe ou volatile ajouté á cette diſſolution n'occaſionnoit pas de changement ſubit, mais quelque tems apres, un precipité; en verſant ſur ce ſel de l'acide marin ou nitreux il ne paroiſſoit aucun mouvement; mais ſi on ſe ſervoit du vitriolique, il éxcitoit une fermentation conſiderable, avec des vapeurs ſemblables á celles que ce même acide occaſionne lors qu'on le verſe ſur du ſel marin deſeché; ce ſel expoſé à lair attiroit l'humidité, çependant pas auſſi promptement que celui dont je parlerai ci apres.

D'apres ces diverſes experiences ne peut on pas conclure, que les eaux de *Boſton*, contiennent un ſel marin a bâſe d'alkali mineral en petite quantité, une plus grande de ſel marin a bâſe terreuſe, une certaine quantité d'hûile, peut être un peu de ſel cathartique amer.

En oûtre, il en eſt qui contiennent deplus une ſur abondante quantité de terre, laquelle m'a parue ſuſpendue au moyen d'une trop grande quantité d'air.

Pour m'aſſurer plus poſitivement et rendre mes experiences plus certaines, je combinai un ſel marin â bâſe terreuſe au moyen de la poudre de corail unie a l'acide marin,

like that of the preceding salt; it was whiter, arising, I suppose, from a difference in the quantity of oil; it more readily absorbed moisture, because it was not combined with salt of an alkaline basis, it did not decrepitate on the coals for the same reason; in other respects, it exhibited the same appearances with the preceding salt.

Much remains to be said, but time and circumstances prevent my enlarging. If this sketch shall be thought of utility, I shall be very agreeably recompenced.

marin, la cristallisation a été la même que celle du sel precédent, mais il etoit plus blanc, cela depend, je crois, d'une difference hûileuse, il attiroit plus promptement l'humidité de l'air par ce q'uil nétoit point mêlé de sel à bâse d'alkali, il ne décrepitoit point sur les charbons par la même raison, au reste, il présentoit les mêmes phénomenes que le precedent.

Il reste encore beaucoup des choses a dire que le tems ni les circonstances ne me permettent pas à present; heureux si cet ésquisse peut etre ûtile, il devienda pour moi une recompense bien flatteuse.

VIII. *Observations on the Longevity of the Inhabitants of* Ipswich *and* Hingham, *and Proposals for ascertaining the Value of Estates held for Life, and the Reversion of them. In a Letter from the Rev.* EDWARD WIGGLESWORTH, *F. A. A. and Hollisian Professor of Divinity in the University of* Cambridge, *to the Honourable* JAMES BOWDOIN, *Esq; Pres. A. A.*

Cambridge, *January* 28, 1782.

HON. SIR,

AFTER the last meeting of the Academy, the Rev. Mr. *Cutler*, of *Ipswich-Hamlet*, put into my hands a bill of the births and deaths in his parish, from September 11, 1771, to September 11, 1781. This bill has been kept with great accuracy; and it serves to shew, so far as a general conclusion can be drawn from the births and deaths in a single parish, that either the climate, or the manner of living on the sea-coast of *New-England*, is very favourable to life.

From the situation of *Breslaw*, and the employment of its inhabitants, Doctor *Halley* supposes that the deaths in that city are more proper for tracing out the probabilities of the continuance of the human life in its various stages, than those of any other large city in *Europe*. His table has accordingly been made the standard for estimating the value of those estates in *Great-Britain* which are held for life.

The Doctor observes, that the people of *Breslaw* are encreased by 1238 *births* annually. Of those it appears, by Dr. *Newman*'s tables, that 348 die *yearly*, in the first year of their age; so that but 890 do arrive at a full year's age; and that 193 die in five years, between one and six, complete; so

so that 692 of the persons born, survive six whole years, and but 710 survive five whole years. Hence it follows, that at *Breslaw* five persons out of twelve that are born, die before they have completed the fifth year of their age. Whereas at *Ipswich-Hamlet*, where, in the course of ten years, 331 persons have been born, but 60 died before they had completed the fifth year; that is but 6 in 33; which determines *Ipswich-Hamlet* to be more than twice as favourable as *Breslaw*, for the preservation of life in its first stages. A similar conclusion may be made with respect to the late periods of life. For by Dr. *Halley's* table, out of 1000 persons who die annually at *Breslaw*, but 34 survive 80 years complete. Whereas at *Ipswich-Hamlet*, out of 164 persons who have died in ten years, 21 persons have survived 80 years complete. At the former place, one in about 30; at the latter, one in about 8 arrive at this great age.

Mr. *Lincoln*, eldest son of the Hon. Major-General *Lincoln*, has been so kind as to favour me with a copy of the Rev. Mr. *Gay's* bills of the baptisms, marriages and burials, in the first parish in *Hingham*, from 1726 to 1779, inclusive. This aged and venerable gentleman has been exceedingly accurate in keeping those bills. The age of every person who has died in his parish for 54 years, is set down in the order of the deaths. This bill will be very serviceable in computing a table of the probabilities of the continuance of life in *New-England*, possibly more so than any others that can be obtained.

This bill I have reduced to the respective years of the human life, and by this means have determined the particular number that have died in each age. From the reduction, it appears, that *Hingham*, as well as *Ipswich*, is more favourable to longe-

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vity than *Breslaw*, the *British* standard of life. At the first parish in *Hingham*, in a period of fifty-four years, 2247 persons have been born; there have been 521 marriages, and 1113 deaths. Of those, 168 have died in the first year, and 404 under five years complete. Out of 1113 persons who have died in 54 years in that parish, 84 persons have survived 80 years complete; whereas at *Breslaw* only 34 out of 1000 survived that age.

These speculations are not designed as a *mere amusement*; they are intended for *a valuable purpose in civil life*. The value of those estates which are held for life, and the reversion of them, can only be determined by knowing the probability which there is, that their respective holders will live for a longer or shorter term of years. Those probabilities are different in different periods of life. The present value of two estates held in dower, whose annual incomes are equal, may be very different. For instance, a widow of 30 years of age has an equal chance of living, according to Dr. *Halley's* table, about 28 years; whereas one of 50 years has only an equal chance of living 17 years. The present value, therefore, of the estates held by them respectively, as well as the value of their reverson, though their annual incomes should be equal, are very different. There has, as yet, been no certain rule established for estimating the value of such estates. Whenever a widow has compounded with the heirs of an estate for a sum of money in lieu of her dower, the composition has been made at random, and not on any fixed principles that have determined it to be equitable.

From the comparison made above, it is evident, that the present value of estates among us, held for life, and the value of the reversion of such estates, cannot be traced with accuracy from the

the *European* tables. If ever it should be effected, tables must be constructed among ourselves; and this can only be done by keeping regular bills of mortality, comparing them together, and making proper deductions from their joint result.

It is therefore to be wished, that those gentlemen who have such bills in their possession, or have it in their power to procure them, would communicate them to the Academy at some future meeting.

I have inclosed the Rev. Mr. *Cutler's* bill, mentioned already, with a request that I may be permitted to take a copy of it. Those of the Rev. Mr. *Gay*, I have been prevented, by ill health, from putting into proper order for laying them before the Academy at their present meeting; but hope to be able to do it before the next meeting of the society.

I am, &c.

EDWARD WIGGLESWORTH.

Honourable *James Bowdoin*, Esquire.

END OF THE FIRST VOLUME.

"Errata" wanting